WILSON'S

ANATOMIST'S VADE MECUM.

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WILSON'S ANATOMIST'S VADE MECUM

A SYSTEM OF

HUMAN ANATOMY.

TENTH EDITION

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PREFACE

TO

THE TENTH EDITION.

THE present Edition of the ANATOMIST'S VADE MECUM has been prepared under the same editorial control as the Ninth Edition, but the labour of production has, on this occasion, been more unequally divided. In consequence of the numerous and increasing demands on his time, Dr. George Buchanan has only found it possible to give a general supervision to the work, and to interest himself in those parts bearing directly on surgical practice. It has therefore fallen to the lot of Mr. Henry E. Clark to perform a revision which has left its mark on every page of the book, and to write those new descriptions rendered necessary by the more extended and exact knowledge of recent years.

The most important changes will be found to consist in the expansion and more complete elaboration of the section on Histology, and the introduction of full-page plates of the bones, with the muscular attachments shown in colours. Among other changes will be noticed the description of the bursæ found in the neighbourhood of joints, the incorporation of the description of the fasciæ with that of the muscles, the introduction of a more exact account of the arterial supply of the brain than has yet found a place in most of our text-books, and a fuller description of the convolutions and sulci of the brain.

The limit of space rendering it impossible to give a complete history of the development of the embryo, it has been thought best to omit the paragraphs relating to the development of the cranium and face and the brain, while such portions of the last chapter on the "Anatomy of the Fœtus" as have been retained, have been incorporated with the description of the individual organs to which they relate.

Numerous additional woodcuts have been introduced; most of them are from works already published by Messrs. Churchill, but a few new ones in the section on Histology have been copied from Dr. Klein's "Atlas of Histology," and his valuable monograph on the "Anatomy of the Lymphatics," that gentleman having very freely granted his permission for their use. Instead of acknowledging the woodcuts individually where they occur, the authors of those borrowed are named in the list of illustrations.

The full-page engravings of the bones have been drawn and engraved by Mr. Stephen Miller of Glasgow, who has been at great pains to secure accuracy, and has endeavoured to make them not mere anatomical diagrams but artistic pictures.

In the revision of the Glossary at the end of the work the Editors have received valuable assistance from Mr. Edward Coyle.

GLASGOW, *October* 1880.

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ANATOMIST'S VADE MECUM.

PART I.

Anatomy is the science which treats of the structure of organised bodies. The word Anatomy (derived from ἀνὰ and τέμνω, I cut asunder), was originally used as synonymous with dissection, but at present it refers to the subject rather than the method of study. Organised bodies are such as are composed of a collection of dissimilar parts or organs, each of which is necessary to our idea of a perfect whole; the absence of one of which would leave a fragment.

Human Anatomy has been divided into Descriptive and General. Descriptive Anatomy is a consideration of the organs or parts of the body with reference to their position, shape, size, connection, &c. General Anatomy is the study of the textures which are found in the body without reference to the organ in which they may exist. At the present day the term has been superseded by that of Histology (ἱστὸς, a web).

HISTOLOGY.

The human body, complicated though it be, is made up of a small number of elementary tissues; these by their different combinations form the several organs, and a knowledge of them is therefore essential to the proper understanding of those organs and their uses.

The solid textures of the body which will be described in this section of the work are as follows:—Cells, epithelium, fibrous tissue, connective tissue, adipose tissue, pigment, cartilage, bone, muscle, nerve, blood-vessels, lymphatic vessels and glands, serous and synovial membranes, mucous membrane, and secreting glands. Some of these are simple in their constitution, and by their combination form the more complex,—such are the cells and fibrous tissues; others are composed of many different constituents arranged often in a very complex manner, and among these are included the blood-vessels, lymphatics, and secreting glands. The latter are here described because it is necessary to consider them apart from the

several organs in which they are found, and because it is convenient to speak of them in connection with the more elementary tissues of which they are constructed.

CELLS AND PROTOPLASM.

Fig. 1.—Different kinds of cells with nuclei and protoplasm; half diagrammatic.

Every tissue in the body in its earliest condition consists of an aggregation of minute solid particles which have received the name of cells. Some of the tissues retain throughout life the cellular character, but these are few in number, the majority only having their origin from cells indicated by the presence of minute remains of them called *nuclei.* Cells are for the most part spheroidal in shape unless modified by pressure or other causes, when they may become oval, fusiform, scaly, or hexagonal; in pigment, connective tissue, and the nervous centres they are stellate, having ramifying processes which communicate with each other so as to form a network. Besides those contained in the tissues there are also free cells floating in the fluid of blood, lymph, and chyle, and one form of these has the power of leaving these fluids and travelling through the tissues; these, the "white corpuscles" of the blood, have hence been termed "*wander cells.*" Each cell consists of an albuminoid material, transparent, colourless, and of a jelly-like consistence called *protoplasm.* The cell may have a distinct bounding membrane or *cell wall*, but this is not invariably the case with the cells of animal tissues; it has usually one or more central spots called *nuclei*, within which again are one or two smaller spots called *nucleoli;* but both nucleus and nucleolus may be absent without interfering with the vitality of the cell. The protoplasm has commonly a granular appearance, and this has recently been ascertained to be due to the existence of a very fine network of fibrils with slight nodes at the points where they intersect (intercellular network); the nucleus also contains a similar network (internuclear network) to which in like manner its granular appearance is in most instances due. Some cells, however, contain bright granules in the midst of these meshes; they are the true granular corpuscles. The protoplasm contracts on the applica-

Fig. 2.—Diagram of a cell with two nuclei, showing intercellular and internuclear network.

tion of a stimulus just as muscular fibre does, and is capable when in the free state of spontaneously changing its shape, as may be seen to take place when a white blood corpuscle is observed with the microscope in the living tissues, or on a warm stage; this is spoken of as *amœboid motion.* Cells are connected with each other either by means of their processes, as above mentioned, by direct union of their walls, or by an intercellular substance.

EPITHELIUM.

The epithelial tissues are distinguished by their retaining the cellular character throughout the whole of life; they are used chiefly for the purpose of protection, but epithelial cells constitute also the secreting cells of mucous membrane and of glands. The superficial part of the skin consists of many superimposed layers of epithelial cells, constituting the *epidermis;* those cells on the surface become flattened and dried, and are cast off as thin scales. Epithelium is also found covering the mucous membranes; it forms a thin smooth lining to the serous membrane lining the cavities of the abdomen, thorax, and skull, lines the inner surface of the heart, blood-vessels, and lymphatics, and also coats the interior of the ducts and the secreting cavities of the glands which open on to the surface of the skin and mucous membrane.

The cells of epithelium present some differences of form and arrangement which give rise to their division into four varieties—namely, squamous, columnar, spheroidal, and ciliated.

1. **Squamous, Scaly,** or **Tesselated Epithelium** is so called because the cells appear as thin flattened scales; they have in their centre a small nucleus and nucleolus which are of soft consistence, the rest of the cell is more dense. They form a single layer on the serous membranes of the cavities of the body and on the lining membrane of the heart, blood-vessels, and lymphatics; but on the skin, the mucous membrane of the oral cavity, lower half of pharynx, œsophagus, lachrymal canal, tympanic cavity, vagina, female urethra, bladder, ureter, pelvis of the kidney, and on the conjunctiva of the eye they form the surface layer of a thick mass of cells, the deeper constituents of which are commonly spheroidal or fusiform in shape. The scales are somewhat larger in the mouth and fauces than elsewhere, and in longest diameter measure $\frac{1}{400}$ to $\frac{1}{300}$ of an inch; in the vagina between $\frac{1}{800}$ and $\frac{1}{500}$; and on the

FIG. 3.—Old epithelium cells from the mouth.

skin $\frac{1}{600}$. The nucleus, which is round or oval in shape, and flattened, measures in scales from the mouth $\frac{1}{2000}$ of an inch. The cells of the mouth and skin overlap each other at their line of contact; on the serous membranes, on the other hand, they join accurately edge to edge, their union being generally indicated by a sinuous or irregular line. Young cells are often observed to be ribbed on their surface and serrated at their edges, they are then called **spinous** or **furrowed** cells.

FIG. 4.—Spinous cells from *rete mucosum.*

2. **Columnar** or **Cylinder Epithelium** consists of cells which have an elongated or pyriform shape, their bases being directed to the free surface, and their apices to the membrane to which they are attached. They are ranged side by side like columns, and are connected together by a small amount of *intercellular* or *cement substance.* Each column contains near its middle a nucleus, which gives it a swollen appearance, and the nucleus possesses one or more nucleoli; from the transparency of the column the nucleus may be seen through its base. This form of epithelium is found in the alimentary canal from the cardiac end of the stomach to the anus, in the intestinal glands, in the mammary and lachrymal glands, in the male urethra, vas deferens, seminal vesicles, Cowper's glands, glands of Bartholine, and uterine glands.

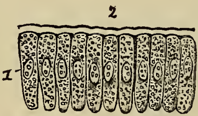


FIG. 5.—Portion of columnar epithelium from one of the villi of the small intestines. 1. Nucleus of the cell. 2. Basement membrane.

FIG. 6.—Columnar epithelium from the small intestine. Separate cells showing nucleus and nucleolus.
FIG. 7.—Appearance of the surface formed by the apposition of the bases of several cells.

3. **Spheroidal, Globular,** or **Transitional Epithelium** is composed of cells which are spheroidal in shape, but often become more or less polyhedral from compression. These cells may also as the result of compression become converted into the squamous or columnar varieties, hence they have been named *transitional* by Henle. This form of epithelium occurs in the glands connected with the skin, the excretory ducts of the kidneys, the deep part of the gastric glands, and in many other glands.

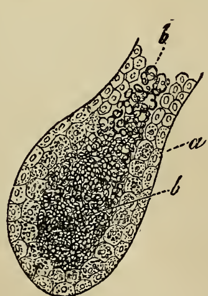


FIG. 8.—Saccule of a sebaceous gland. *a.* Gland cells clothing the walls. *b.* Those which have been cast off, filled with oil globules, and occupying the lumen of the sac.

4. **Ciliated Epithelium** is characterised by the presence of minute

conical vibratile filaments or *cilia* mounted on the broad ends of columnar cells, or upon the free surface of those of the spheroidal kind. The cilia are in constant action, and produce a wave-like motion, which carries the secretions in contact with them towards the outlet of the organ in which they exist. They have an average measurement in the human trachea of $\frac{1}{4000}$ to $\frac{1}{2500}$ of an inch. Ciliated epithelium is found as a single layer of columnar cells in the finest bronchial tubes, the accessory cavities of the nose, on the inner side of the membrana tympani, in the Eustachian tube, in the uterus and the Fallopian tubes. Forming the free surface of stratified epithelium, it exists in the larynx, trachea, bronchi, larger bronchial tubes, nasal cavities (except the floor, the olfactory region, and the upper part of the pharynx). Spheroidal ciliated cells exist only in the cerebral ventricles, where they are found as a single layer lining those cavities. Many of the cells communicate by their attached ends with cells situated in the deeper tissues, by fine elongated processes.

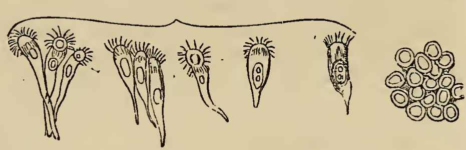


FIG. 9.—Cells of the columnar ciliated epithelium of the nose, magnified 310 times.

FIG. 10.—Appearance of the surface formed by the apposition of the bases of the columnar ciliated epithelium.

FIG. 11.—Various forms of ciliated epithelial cells, with processes communicating with connective-tissue corpuscles.

Some epithelial cells have a dictinct bounding wall or limiting membrane, others are devoid of it; when it exists it results from a hardening of the superficial layer of the cell substance. The cells contain an intercellular network, and the nuclei an internuclear network of fine fibrils.

CONNECTIVE TISSUE.

Connective tissue forms the means of union between the several tissues and organs, forms coverings for the muscles and sheaths for the vessels, and constitutes the supporting framework for the

cellular and other elements which make up the individual organs. It consists of fibres and of cells, the former greatly preponderating, and being easily divisible into two sets, elastic and non-elastic. Having many and various duties to perform, connective tissue is necessarily greatly diversified in its arrangement, differing also in different regions in the proportion of cells to fibres, and of the elastic fibres to the non-elastic. We may, however, readily distinguish three chief forms of connective tissue, each of which requires a separate and complete description; these are the **areolar** (including the **adipose**), the **fibrous**, and the **elastic**.

Areolar Tissue.—This consists of delicate fibres and transparent laminæ crossing each other in all directions, and leaving between them irregular interspaces or meshes, called *areolæ;* these are occupied by a small quantity of clear colourless fluid, sufficient only to keep the threads and laminæ moist. In the midst of the fibres and laminæ, we can by the use of reagents demonstrate the existence of numerous branched and anastomosing cells, the *connective tissue corpuscles;* they are composed of protoplasm, which is in some transparent, in others granular, and they have a clear nucleus, and often one or more nucleoli. The cells lie in a gelatinous semi-fluid substance, (called the *ground substance*) which joins the fibres of the tissue together, making them into bundles, occupying in it cavities (called "cell spaces") which correspond accurately to the shape and size of each cell. Besides the branched cells, there are also found in areolar tissue a number of migratory or wander cells, like the white corpuscles of the blood, composed of protoplasm, and containing one or more nuclei. These cells have the power of moving from place to place, and they become especially numerous when the tissue undergoes inflammation. The fibres are very fine, measuring from $\frac{1}{50000}$ to $\frac{1}{25000}$ of an inch, and are apparently structureless. By

FIG. 12.—A portion of living connective tissue, cut out from between the muscles of the frog's thigh (highly magnified). *a.* A pale contracted cell. *b.* Ramified corpuscles. *c.* A similar corpuscle with vesicular nucleus. *d* and *e.* Motionless, coarsely granular cells. *f.* Fibrillæ. *g.* Bundles of connective tissue. *h.* Elastic fibrous network.

means of the ground substance, they are united into bundles, which have a wavy course, and when viewed by reflected light, have a white and shining appearance. Mixed with these, we commonly find a number of coarser fibres having a tendency to curl at their ends, and not gathered into bundles; acetic acid, which causes the bundles of fibres to swell up and become indistinct, has no effect on these single fibres; they will be more fully described in a later page as *yellow* or *elastic fibres.* From the loose arrangement of areolar tissue, it is often subjected during life to infiltration of fluid, this constituting *anasarca.*

Adipose Tissue or Fat may be described as areolar tissue, the meshes of which are occupied by vesicles containing oil. It is chiefly found immediately beneath the skin, forming there a continuous layer over nearly the whole surface of the body, the *panniculus adiposus;* it also exists very plentifully in the mesentery and omenta of the abdomen, round the joints, on the surface of the heart, and entering into the formation of the marrow of bones. It consists of vesicles which measure from $\frac{1}{500}$ to $\frac{1}{300}$ of an inch, filled with oil; they are aggregated together so as to form little masses or lobules, and are contained in the meshes of areolar tissue. A nucleus generally exists at one side of the vesicle, but is commonly obscured by the oily contents; it is the remains of the protoplasm of the cell from which the vesicle was formed. The vesicles are usually globular in form, unless they have been compressed, when they become hexagonal or polyhedral. After death the contents of the vesicles often crystallise, appearing as groups of fine acicular crystals, which are supposed to consist chiefly of margaric acid.

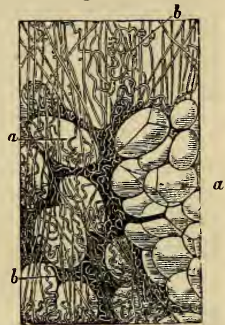


Fig. 13.—Areolar and adipose tissue. *a, a.* Fat cells. *b, b.* Fibres of areolar tissue.

Fig. 14.—Fat vesicles from omentum, showing nuclei at the margins of the vesicles.

Each lobule of fatty tissue has entering it a small artery, and leaving it a small vein, these being connected together by a very fine plexus of capillary vessels.

Fibrous Tissue.—This tissue forms the periosteum of bones, ligaments to bind the bones together, tendons for the attachment of muscles, strong protecting coats for certain organs, and fasciæ to separate the muscles from each other. Thus two forms of it are described—the *fasicular*, where the fibres are gathered up into bundles so as to form a rounded or flattened band, and *membranous*, where they are spread out so as to

form a thin sheet. It is composed of fine filaments gathered into bundles, and having all the characters and properties of the white fibres described as forming the greater part of areolar tissue. These are either arranged parallel to each other as in the formation of tendons and ligaments, or they spread out, cross, and get interwoven, so as to form a membranous sheet as in fasciæ and sheaths of muscles. In the fasicular form white fibres exist almost exclusively; in the membranous form there is a slight admixture of yellow elastic fibres.

Fig. 15.—White or non-elastic fibrous tissue.

When a tendon is treated with acetic acid the white fibres of which it is composed swell up and become transparent; there are then brought into view chains of oblong flattened cells lying between the tissue bundles; these are nucleated, the nuclei of adjoining cells usually lying side by side. By the use of reagents it can be shown that these cells lie in cell spaces similar to those already described as lodging the cells of areolar tissue; the cell spaces accurately correspond in size and shape to the cells which they lodge.

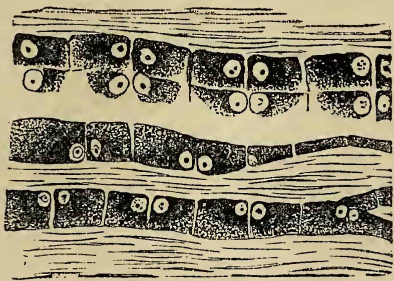


Fig. 16.—Caudal tendon of a young rat, showing the arrangement and form of the tendon cells.

Fibrous tissue is white and glistening; it is very strong, but is inelastic, unless when intermixed with yellow fibres. It is converted into gelatine by boiling.

Yellow Fibrous Tissue or **Elastic Tissue** enters very generally into the structure of tissues and organs in which the property of elasticity is an important quality, and serves the additional purpose of binding structures together. As an elastic and binding element it is present in the common areolar tissue and superficial fascia, in the fascial sheaths of muscles, in the fibrous capsules of different organs, as of the spleen, in the corium of the skin, in serous and mucous membranes, in the coats of blood-vessels and ducts; and, in certain situations, is the sole tissue present, as in the ligamenta subflava, chordæ vocales, thyro-epiglottic ligament, crico-thyroid membrane, lateral thyro-hyoid ligaments, the membranous layers connecting the cartilaginous rings of the trachea

and bronchial tubes, the ligamentum nuchæ, and ligamentum suspensorium penis. It is also met with around some parts of the alimentary canal, as the œsophagus, cardia, and anus, and around the male and female urethra.

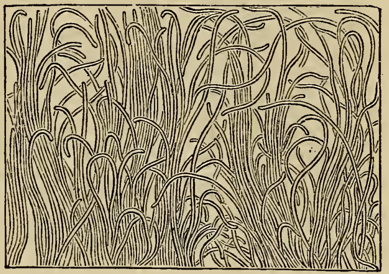


Fig. 17.—Yellow or elastic fibrous tissue, from ligamentum nuchæ.

The fibres of elastic tissue are cylindrical or flattened, brittle, colourless when single, but yellowish in an aggregated form, elastic, admitting of being stretched to double their length and returning to their original size, and variable in dimensions, ranging from extreme fineness to a considerable breadth. They present themselves, therefore, in the two forms of *fine* and *coarse*, and are distributed among the textures of the body either as single and *isolated filaments* or as a *network*.

Isolated elastic fibres of extreme fineness are met with coiled around or entwined among the fasciculi of areolar tissue, holding them together.

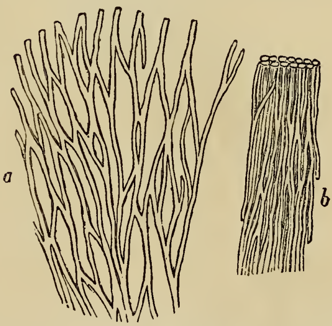


Fig. 18.—Anastomosing form of yellow fibrous tissue. *a*. The fibres drawn apart to show the reticulate arrangement. *b*. The fibres *in situ*.

The *elastic network* formed by these fibres may be extremely fine and delicate as in thin membranes; or it may be coarser, as in the various ligamentous bands composed of this tissue; or it may be spread out like a membrane, the interstices forming but a small part of its extent, as in the *fenestrated membrane* of the arteries. In the construction of yellow elastic ligaments, the fibres communicate with each other by means of short oblique bands, which unite with adjoining fibres at acute or obtuse angles without any enlargement of the fibre with which they are joined. This circumstance has given rise to the idea of the fibres giving off branches, an expression derived from the division of blood-vessels, and another term borrowed from the same source has been applied to their communication with each other—namely, inosculation; but both these expressions in their literal meaning are incorrect. When yellow fibrous tissue is cut or torn, the fibres, in consequence of their elasticity, become

clubbed and curved at the extremity, presenting a curled appearance which is a special character of this tissue.

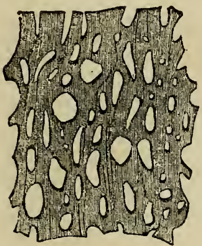


Fig. 19. — Fenestrated membrane from the middle coat of the carotid artery of a horse.

Special Varieties of Connective Tissue.—Of these, three kinds deserve special mention, namely, **mucous tissue, reticular tissue**, and **simple membrane.**

Mucous Tissue forms the chief part of the umbilical cord (the Whartonian gelatine), and also forms the vitreous humour of the eye. In the early embryonic condition all connective tissue consists of a pellucid jelly, in which nucleated corpuscles are embedded, and yields a chemical principle called *mucin;* in the vitreous humour the cells disappear, only the jelly remaining, but in the umbilical cord the corpuscles branch and become connected so as to form trabeculæ, between which the jelly lies.

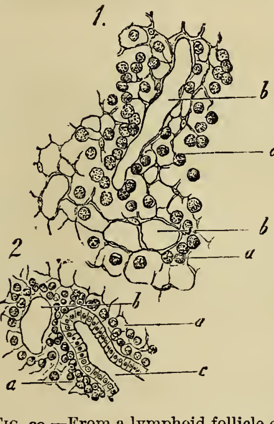


Fig. 20.—From a lymphoid follicle of the vermiform appendix of a rabbit. 1. Reticular tissue, with the system of meshes, *b*, and remains of the lymph cells, *a*. Most of the latter have been removed artificially.

Reticular Tissue is found in all lymphatic glands, in the pharynx, and tonsils, the solitary and agminate glands of the intestine, the thymus gland, and in the spleen. It consists of ramified nucleated cells, the branches of which are so connected with each other as to form a network, the meshes being commonly filled with lymph corpuscles. From its presence in lymphatic glands it has been named "adenoid" and "lymphoid" tissue.

Simple Membrane was formerly supposed to be structureless, but is now known to be made up of flattened cells united edge to edge. It forms the walls of the capillaries, the hyaloid membrane of the eye, and the membrane beneath the epithelial cells of mucous membrane, formerly called *basement membrane.*

PIGMENT.

Pigment of a black or dark brown colour is found in the deeper layers of the cells of the epidermis (rete mucosum), especially in certain regions, as the perineum, scrotum, and penis, also in the choroid coat of the eye, the olfactory mucous membrane, the

pia mater of the spinal cord, and the lungs. It consists of minute granules composed chiefly of carbon, embedded in the protoplasm of epithelial or other cells, so as often completely to obscure the colourless and transparent nucleus; the granules often exhibit movements in the substance of the containing cell. The cells are sometimes hexagonal in form, and arranged side by side as in the pigmentary layer of the choroid coat of the eye, sometimes they are round, as in the rete mucosum of skin, or are, again, stellate in shape, as in the lamina fusca of the choroid. The stellate pigment cells of the skin of the frog have been observed to change their shape under various forms of irritation, chemical, electrical, and mechanical, these processes becoming shorter and less numerous, and at length being retracted into the body of the cell, which thus becomes spheroidal.

FIG. 21.—Pigmentary connective-tissue corpuscles (so-called stellate pigment cells), from the *lamina fusca* of the eye.

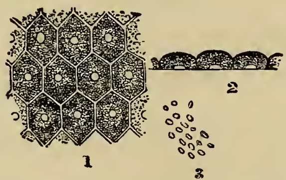


FIG. 22.—Pigmentary layer of the choroid. 1. The cells as seen from the surface. 2. The same viewed edgeways. 3. The fine pigment which fills the cells.

CARTILAGE.

Cartilage or gristle is a firm but easily cut, elastic, bluish-white substance which coats the articular ends of long bones, joins the ribs to the sternum, forms grooves for the passage of tendons, and in the embryo and young child occupies the place of bone, and is the substance from which that tissue is formed.

Three forms of cartilage are usually distinguished, **hyaline, reticular,** and **fibro-cartilage.**

Hyaline Cartilage, sometimes spoken of as **true cartilage,** is composed of a semi-transparent homogeneous substance called the *matrix*, containing a number of minute cells dispersed at short intervals through its structures. The cells may be evenly distributed throughout the matrix, as is the case in fœtal cartilage, or may be gathered into groups, the members of which by their mutual pressure become changed in shape, and from being round or oval as the single cells are, become flattened on one or two of their sides where they are in contact with their fellows. The cells have an average measurement of about $\frac{1}{1000}$ of an inch; they lie in the matrix in cell spaces which are bounded by a capsule,

which, however, is often indistinguishable in young cartilages. The matrix is permeated by numerous very fine channels, which also pierce the capsules of the cartilage cells, and thus the cavities in which the cells lie come to communicate with each other; these channels are believed to be connected with the lymphatic system. The matrix in some instances has fibres formed in it, as for instance in costal cartilage. Hyaline cartilages have been divided into *temporary*, which ultimately become converted into bone, and *permanent*, which remain throughout the whole of life; the majority of the latter are *articular*, that is, they coat the ends of the bones entering into the formation of joints.

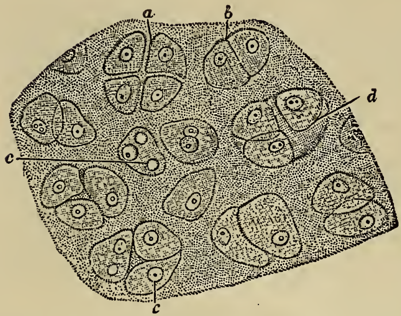


Fig. 23.—Branchial cartilage of a tadpole. *a.* Group of four cells separating from each other. *b.* Pair of cells in apposition. *c, c.* Nuclei of cartilage cells. *d.* Cavity containing three cells.

Reticular Cartilage, or **Elastic Cartilage,** is composed of cells ($\frac{1}{1500}$ of an inch in diameter), separated from each other by an opaque, fibrous, intercellular network, the breadth of the cells being considerably greater than that of the intercellular structure. The cells contain nuclei, granular matter, and oil globules, the latter in greater number than in true cartilage; the fibres are short, imperfect, loose in texture, and yellowish; and chemically there is an absence of chondrine. Instances of reticular cartilage are, the pinna, epiglottis, and Eustachian tube.

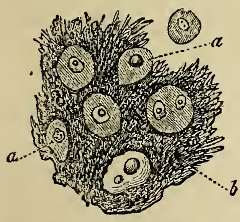


Fig. 24.—Reticular cartilage, from the epiglottis.

Fibro-Cartilage is composed of an interlacement of fasciculi of white fibrous tissue, containing in its meshes scattered groups of cartilage cells; and the difference of density of different fibro-cartilages is referable to the greater or less abundance and more or less condensed state of the fibrous tissue. In some, as in interarticular cartilages, the fibrous element exists in a concentrated form, while in the intervertebral substance it is loose, and contains an abundance of areolar spaces.

Fibro-cartilages admit of arrangement into four groups: interarticular, stratiform, interosseous, and circumferential. Instances of *interarticular fibro-cartilages* (menisci) are those of the lower jaw, sternal and acromial end of the clavicle, wrist, and knee. The *strati-*

form fibro-cartilages are such as form a thin coating to the grooves on bone through which tendons play. The *interosseous fibro-cartilages* are the intervertebral substance and cartilage of the symphysis pubis. The *circumferential fibro-cartilages* are the glenoid and cotyloid.

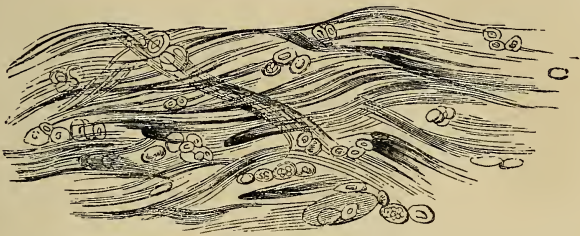


FIG. 25.—A portion of fibro-cartilage. The section is made from the symphysis pubis, and magnified 155 times.

Cartilages, excepting those of joints, have their free surfaces covered by a fibrous membrane called the *perichondrium.*

BONE.

Bone is composed of about one-third of animal substance, which is almost completely reducible to gelatine by boiling, and two-thirds of earthy and alkaline salts. The special constituents of bone are present in the following proportions :—

Animal matter	33 parts.
Calcium triphosphate	57 ,,
Calcium carbonate	8 ,,
Calcium fluoride	1 ,,
Magnesium phosphate	1 ,,
	100 ,,

Structure of Bone.—On examining the section of a bone, it will be found that there are two varieties of osseous tissue : one forming the exterior—hard, compact, dense ; the other occupying the interior —spongy, cellular, cancellated. The best way to obtain a correct idea of the arrangement of bone substance is to study the appearance presented by a long bone, such as the tibia, which has been sawn longitudinally. The shaft is a hollow pillar, the walls of which are formed of dense bone. The hollow interior is the medullary cavity, and in the recent state is filled with marrow. The upper and lower enlarged ends are formed of an exterior thin shell of compact bone which surrounds a beautiful spider-weblike latticework of osseous threads, the meshes of which are also filled with marrow. After complete maceration all the membranous and oily matters are removed, and the dried bony structure alone is visible.

On close observation, it will be seen that the walls of the pillar consist of fibres or plates arranged in the direction of the bone, and that the cancellated texture of the extremities is formed by the separation and divergence of threads of bone which proceed in the same direction as the walls till they reach and support the thin shell which encases the spongy texture of the end. The fibres diverge and decussate like the divisions of a Gothic window, and so enclose lozenge-shaped spaces, which are the cancelli. This arrangement, which always has reference to the direction in which the bone is to bear pressure, adds greatly to the strength of the loose light part of the bones; and this is further secured by little cross bars, which tie together the long slender fibres just described. The dense and spongy tissues are essentially the same in structure, and the difference is simply in the degree of closeness with which the fibres are packed. A perpendicular section of the body of a vertebra shows an example of reticular or cancellated texture where the bars are parallel and straight, in accordance with the direction of the pressure.

FIG. 26—Section of head of tibia, to show the cancellated texture.

In flat bones the osseous substance is arranged as two plates of dense tissue, in some parts closely contiguous to each other, as in the scapula; in others separated by loose tissue, or even by hollow spaces, as in the bones of the skull, where the intervening substance, in which the blood-vessels run, is called the *diploë*.

FIG. 27.—Section of the body of a vertebra — perpendicular and transverse bars. 1. Opening for vena basis vertebræ.

The simplest arrangement of bone substance is to be found in the ethmoid and spongy bones of the face, the thin partitions of which are formed of a single plate of bone. This is nourished from the outside, no vessels entering into its substance.

Bone substance exists in the form of plates or lamellæ, which can be seen by examining a thin slice of bone which has been softened by steeping in diluted hydrochloric acid. The fibrous character of the lamella can be demonstrated by tearing strips from softened bones, by which it will be seen that the direction of the plates is in that of the length of a bone. The further description of the minute structure will be simplified by considering the mode of nourishment of bone.

Periosteum.—This is a fibrous membrane which covers the exterior of all bones, except where they are encrusted with cartilage. It is a tough unyielding tissue, which adds to the strength and elasticity of the bones, and adhering very firmly, forms the means of

attachment of the muscles and tendons. Its principal use is to afford a support and bed to the vessels entering the bone, and it may therefore be called the nourishing membrane to the exterior of the bone. When the periosteum is removed from bone by accident or disease, *necrosis*, or death of the bone, usually happens; and conversely, when a piece of diseased bone can be removed without destroying its periosteum, in many instances the bone, or a portion of it, is reproduced from the membrane. This has given rise to the *sub-periosteal* method of excising bones.

Medullary Membrane or Endosteum.—The hollow shafts of long bones and the open or spongy texture are filled up with marrow or bone fat. This consists of minute oil vesicles, among which blood-vessels ramify, contained in the meshes of a delicate areolar tissue, which also forms a thin lining membrane to the hollow of the bone, hence called the medullary cavity. This medullary membrane is freely supplied with blood-vessels, which reach it through openings, numerous and small, at the extremities of long bones, and by a single vessel of considerable size which enters about the centre of the shaft through a channel called the nutrient foramen. The inner surface of the bone and the walls of the cancelli on which this membrane is applied, derive their nourishment from its blood-vessels, and processes of it extend into small canals in the dense tissue presently to be noticed.

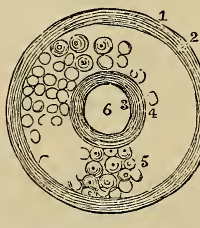


Fig. 28.—Plan of a section of a long bone. 1. Periosteum. 2. Periosteal layer of bone. 3. Medullary membrane. 4. Medullary layer of bone. 5. Dense tissue beyond the reach of the periosteal and medullary vessels constituting the Haversian system. 6. Medullary cavity.

Minute Structure of Bone.—A certain thickness of the exterior of a bone and a similar amount of the inner surface derives its nourishment from the above two membranes, but in most bones there is a considerable amount of dense tissue, which is too far removed from either to draw its support from it.

This intervening portion is supplied by blood-vessels which enter little channels provided for the purpose. These *Haversian* canals, as they are called, are little tubes running for the most part in the direction of the length of a bone, but so obliquely as to form frequent communication with each other, and those near the external and internal surfaces with these surfaces respectively. The whole dense substance therefore is permeated by a network of tubules, so that when a thin transverse slice of bone is examined by the microscope, it is seen to be riddled with circular holes. The Haversian canals measure from $\frac{1}{1000}$ to $\frac{1}{250}$ of an inch in diameter. A perpendicular section shows the communications with each other and with the surfaces of the bone.

That portion of the dense tissue which derives its nourishment from the Haversian canals is arranged in concentric lamellæ round these tubes, so that a long bone may be described as a series of

hollow rods, the central canals of which are the Haversian tubes, bound together by an exterior wrapper consisting of several layers of lamellæ (see fig. 28).

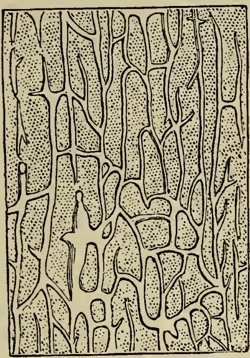


Fig. 29.—Vertical section of tibia, showing the network of Haversian canals.

A further provision exists for bringing the nutritive fluid into more close relation to the bone substance than can be accomplished by the vascular membranes or Haversian canals. The whole of the dense tissue is permeated by extremely minute channels called *canaliculi.* These pass through the periosteal and medullary layers at right angles to their surfaces, and radiate from the Haversian canals. They are smaller in calibre than the smallest capillaries, and serve to conduct the nutritive fluid to the denser tissue. The canaliculi which radiate out from the Haversian canals are interrupted in their passage to the more distant concentric lamellæ by pouring their contents into little oval cavities called the *lacunæ* of bone. These are arranged in circles between the lamellæ, and into their sides next the canals numerous canaliculi enter, while from the further side still more numerous canaliculi diverge towards the circles of lacunæ further out. The lacunæ therefore serve as reservoirs into which fluid from the vessels in the Haversian canals is poured on the one hand, and on the other they pass it on to the outer circles of bone. In this way the nourishment of those parts of bone most distant from the nutrient membranes is provided for by this intricate series of little channels and communicating reservoirs (fig. 30). A thin section of bone is one of the most beautiful of all microscopic objects.

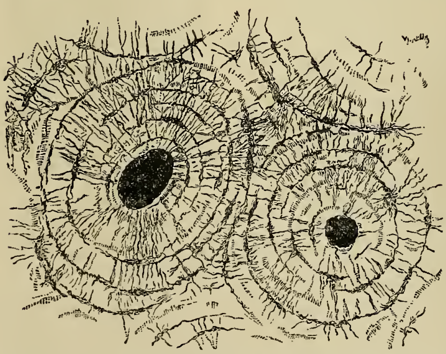


Fig. 30.—Transverse section of a long bone, showing the Haversian system, the canals, concentric lamellæ, canaliculi, and the lacunæ.

The lacunæ were at one time called the "osseous corpuscles," from the idea that they were solid dark particles. The cause of the miscon-

ception was that, during the grinding of a layer of bone the finer porosities get filled up with the *débris*, and by transmitted light appear black, so that a very much magnified view of a "corpuscle" and its canaliculi resembles a black insect—the lacuna representing the body, the canaliculi the legs.

In recent bones the lacunæ are occupied by nucleated masses of protoplasm, and the canaliculi by slender threads of the same substance, by means of which the masses in the lacunæ communicate with one another.

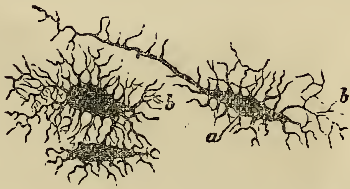


Fig. 31.—Lacunæ of osseous substance, magnified 500 diameters. *a*. Central cavity. *b*. Its ramifications or canaliculi.

The lacunæ and their corresponding canaliculi are to be found in all parts of a bone, and in bones however thin—although Haversian canals are only found in those of some thickness. In the periosteal and medullary layers of long bones, and in very thin bones, their arrangement has reference to the surface of the bone, as it had in the Haversian system; the flat of the oval being turned toward the nutrient membrane, so that their canaliculi may communicate with it for the absorption of fluid nourishment.

Medulla or Marrow of Bones.—Marrow occurs in two forms. In the medullary cavities of long bones it is found of a pale yellow colour, and consists of fine connective tissue supporting fat vesicles; in the cancellated ends of long bones and in short bones, but especially in the cranial *diploë*, it is reddish in colour, contains little fat, and is remarkable for the presence of a large number of round granular cells resembling the white corpuscles of the blood (lymphoid cells). In both kinds of marrow there are also found large isolated cells with many nuclei, called *giant cells* or *myeloplaxes*.

Development of Bone.—The majority of the bones are developed from cartilage, which forms a mould of the same shape as the bone to be formed, but the tabular bones of the skull and nearly all the bones of the face are formed between two layers of membrane without the presence of cartilage, and after the bones have been once formed, their further enlargement or growth takes place chiefly by the deposit of osseous matter beneath the periosteum. We have thus three modes of ossification—*intracartilaginous*, *intramembranous*, and *subperiosteal* —but the two latter being essentially the same, only two forms fall to be described here.

Intramembranous Ossification.—The bones formed without a preceding cartilaginous matrix are, the upper part of the frontal, parietal, upper part of occipital, nasal, lachrymal, palate, vomer, zygoma, upper and lower jaws, and inner layer of sphenoidal spongy bones (Kölliker). If we examine a parietal bone about the period of

commencing ossification, we shall find that the intermediate space between the integuments on the outside and the dura mater within is occupied by a membranous structure consisting of delicate translucent fibres, among which fusiform and stellate cells are distributed. In the centre of the bone a deposition of calcareous salts takes place in this membrane, and spreads from the centre towards the circumference in radiating lines, connected together by transverse bars irregularly disposed. The osseous spiculæ are coated over with a soft transparent substance which has been called "osteogen," and upon this groups of cells may be observed. The cells are very closely aggregated so as often completely to cover the spicules; they are granular in character, and of large size, and, as it is believed that they are the active agents in the production of bone, they have been named "osteoblasts." Many of the cells get embedded in the new bone, and, being compressed by it, become irregular in outline; they give off fine thread-like processes, by means of which they communicate with neighbouring cells. From the presence of these cells and their processes, cavities and canals are necessarily left in the new bone, and these form the lacunæ and canaliculi. As the ossification commences in the centres of the tabular bones and spreads to the circumference, their angles are necessarily the last to ossify, so that at the time of birth, and for some months afterwards, spaces are left between the bones, filled by membrane only.

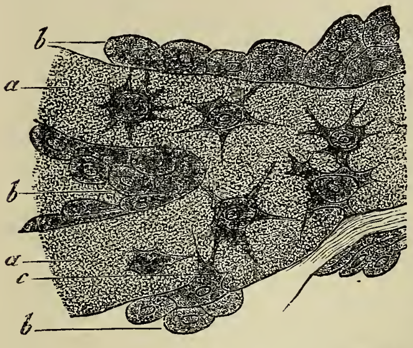


FIG. 32.—Osteoblasts from the parietal bone of a human embryo thirteen weeks old. *a.* Bony septa, with the cells of the lacunæ. *b.* Layers of osteoblasts. *c.* The latter in transition to bone corpuscles.

Intracartilaginous Ossification.—Before the commencement of ossification, the cartilage cells are small in size, have a rounded form, and are evenly distributed throughout the matrix. The first indication of approaching ossification is, that these cells become more numerous, increase in size, and become oval in form. Blood-vessels also, which have hitherto been absent, are now observable in the softened and changing cartilage; these grow from the perichondrium in tufts, and are surrounded by a layer of imperfectly formed connective tissue. Another noticeable feature may also be observed in a section of a bone in which ossification has commenced, namely, that near the ossific centre, the cartilage cells come to be arranged in rows placed vertically to the surface of the new bone.

Between these rows calcareous matter gets deposited, forming trabeculæ, and as development advances, bands are thrown across to

FIG. 33.—Figures illustrative of the development of bone. A. A portion of cartilage the farthest removed from the seat of ossification, showing simple nucleated cells, having an ordinary size of $\frac{1}{2000}$ of an inch, long diameter. B. The same cartilage nearer the seat of ossification; each simple cell has produced two, a little larger than the cells in figure A.

join neighbouring trabeculæ; the rows of cartilage cells come thus to be enclosed in spaces, the walls of which are formed by calcareous matter. The capsules of the cartilage cells undergo partial calcification and partial solution, but the changes which take place in the cells themselves have never yet been satisfactorily followed; some observers believe them to originate by division of their protoplasm the small round cells to be presently described under the name of "osteoblasts," while others believe the latter to originate independently of the protoplasm of the cartilage. However this may be, at the time when we lose sight of the cartilage cells, the cavities with calcareous walls the origin of which has just been traced (and which are called "primary areolæ") are found to be occupied by numerous small granular cells, each with one or two nuclei; these are the "osteoblasts," which either have originated from the cartilage cells, or are migrated white corpuscles of the blood. The cavities now become further enlarged by the liquefaction of

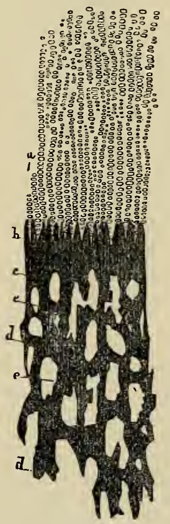


FIG. 34.—Vertical section through cartilage and incipient bone of the shaft of the femur of an infant a fortnight old. *a.* Rows of cartilage cells. *b.* Line of ossification. *c.* Close osseous network, first formed. *d.* Looser structure resulting from reabsorption.

the calcified cartilage at numerous points, so as to form large spaces, having a sinuous form, and called "medullary" cavities; these are lined by thickly packed layers of osteoblasts. Some few of the osteoblastic cells become converted into scattered connective tissue, others retain their original shape, and form the round or lymphoid cells of the medulla, while the larger number are the active agents in the production of bone. They secrete an opalescent substance which lines the medullary sinus, and in which a deposit of calcareous salts takes place; as this deposition advances, layer after layer of the cells takes part in the process, and the deposition in successive layers around the central vessel results in the formation of concentric laminæ around the Haversian canal. Many of the cells become embedded in the new deposit, and remain throughout life, the cavities in which they lie constituting the lacunæ, and by their communication with neighbouring cells they establish a series of smaller pores in the bone, which we have spoken of as canaliculi.

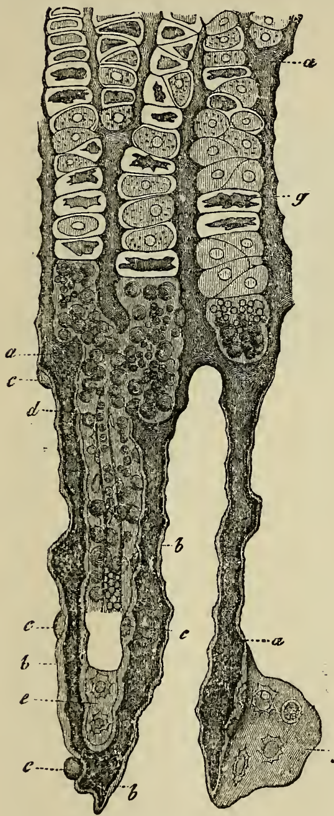


FIG. 35.—Vertical section from the edge of the ossifying portion of the shaft of a long bone. *a.* Cartilage. *b.* Bone. *c.* Newly-formed bone cells in profile, more or less embedded in intercellular substance. *d.* Medullary cavity in process of formation with vessels and medullary cells. *e, f.* Bone cells on their broad aspect. *g.* Cartilage capsules arranged in rows, and partly with shrunken cell bodies.

The growth of long bones takes place in length by the further ossification of the growing cartilage between the shaft and extremity, and in thickness by the deposition of new bone between the periosteum and the shaft, this being always accompanied by reabsorption of the interior, so that the medullary canal becomes increased in size. Subperiosteal growth takes place by a process identical in all essential particulars with what we have described above as intramembranous ossification.

Cartilaginification is complete in the human embryo at about the

sixth week; and the first point of ossification is observed in the clavicle at about the fifth week. Ossification commences at the centre, and thence proceeds towards the surface; in flat bones the osseous tissue radiates between two membranes from a central point towards the periphery, in short bones from a centre towards the circumference, and in long bones from a central portion, *diaphysis*, towards a secondary centre, *epiphysis*, situated at each extremity. Large processes, as the trochanters, are provided with a distinct centre of development.

MUSCLE.

Muscles are the moving organs of the animal frame; they constitute by their size and number the great bulk of the body, upon which they bestow form and symmetry. In the limbs they are situated around the bones, which they invest and defend, while they form to some of the joints a principal protection. In the trunk they are spread out to enclose cavities and constitute a defensive wall, capable of yielding to internal pressure, and again returning to its original position.

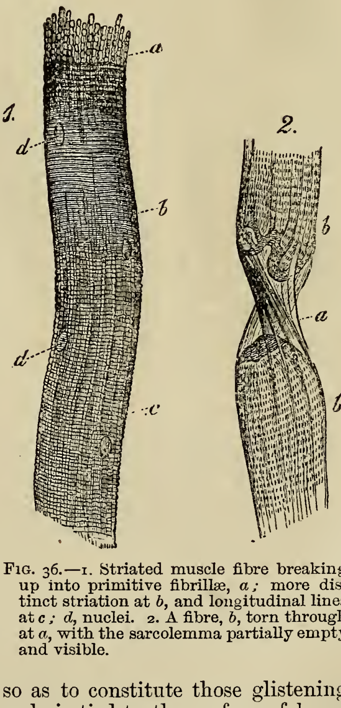


FIG. 36.—1. Striated muscle fibre breaking up into primitive fibrillæ, *a*; more distinct striation at *b*, and longitudinal lines at *c*; *d*, nuclei. 2. A fibre, *b*, torn through at *a*, with the sarcolemma partially empty and visible.

Their colour presents the deep red which is characteristic of flesh, and their form is variously modified, to execute the varied range of movements which they are required to effect.

Muscle is composed of a number of parallel fibres placed side by side, and supported and held together by a delicate web of areolar tissue; so that, if it were possible to remove the muscular substance, we should have remaining a beautiful reticular framework, possessing the exact form and size of the muscle without its colour and solidity. Towards the extremity of the organ the muscular fibre ceases, and the fibrous structure becomes aggregated and modified, so as to constitute those glistening fibres and cords by which the muscle is tied to the surface of bone,

and which are called *tendons.* Almost every muscle of the body is connected with bone, either by tendinous fibres, or by an aggregation of those fibres constituting a tendon; and the union is so firm that, under extreme violence, the bone itself breaks rather than permit the separation of the tendon from its attachment.

Muscular fibres are of two kinds, **voluntary** and **involuntary**; the former are the most numerous, forming the great muscular masses which move the several parts of the body; the involuntary muscular fibres assist in forming the walls of the hollow viscera, and the middle coat of arteries and veins; they are also found in the iris, ciliary muscle, and the bronchial tubes. Peculiarities in their structure also lead to muscular fibres being distinguished as **striated** and **non-striated,** the striated being voluntary in their action, and the non-striated involuntary, with the exception of the heart, which, although involuntary in its action, is composed of striated muscular fibre.

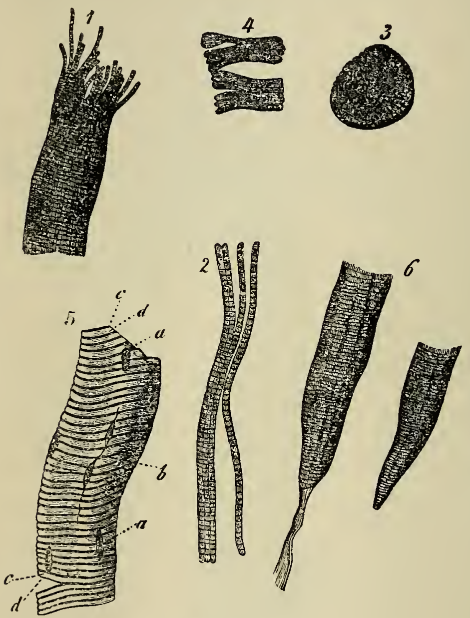


FIG. 37.—1. A muscle fibre with primitive fibrillæ and transverse striation strongly marked. 2. Isolated fibrillæ. 3. Sarcous elements united, forming a disc. 4. Plates of muscle after treatment with hydrochloric acid. 5. A fibre after prolonged treatment with hydrochloric acid with dark (*c*) and light (*d*) zones and nuclei (*a*, *b*). 6. Two pointed fibres from the human *biceps brachii*. From one of them the interstitial connective tissue is prolonged over the end.

Striated or voluntary muscular fibres (called also muscular fibres of animal life) are collected into bundles, held together by delicate areolar tissue, and enclosed in a sheath or perimysium, formed also of areolar tissue, with an admixture of elastic tissue; these bundles are called *fasciculi*, they are prismatic in shape, and of different sizes in different muscles, the apparent coarseness or fineness of a muscle depending chiefly on the size of the fasciculi. The fibres themselves are cylindrical, or oval in

shape, and are nearly uniform in size. According to Bowman they average $\frac{1}{454}$ of an inch in the human female, and $\frac{1}{352}$ in the male, the average of both being in round numbers $\frac{1}{400}$. Each fibre is enclosed in a sheath of transparent, apparently homogeneous, membrane, the *sarcolemma* or *myolemma*. So delicate is this structure that it only becomes visible when the contained fibrils become ruptured, as in fig. 36. It is rather tough, and resembles elastic tissue in its physical and chemical properties. When examined under a high microscopic power the fibres are found to be marked at regular intervals by transverse striæ; these are the characteristic markings which distinguish this kind of muscle, not only from the unstriped variety, but also from every other tissue in the body. The stripes are alternately light and dark, each stripe being about $\frac{1}{17000}$ of an inch in width. The light stripe is often crossed by a fine dotted line or secondary dark stripe. Some anatomists suppose that the dark portions are occupied by a peculiar semi-fluid material, called "*sarcous matter*" (the individual dark spaces being called "*sarcous elements*"), and the lighter portions of a more fluid and hence less highly refracting matter.

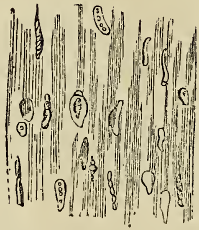


Fig. 38.—Mass of ultimate fibres from the pectoralis major of the human fœtus, at nine months. These fibres have been immersed in a solution of tartaric acid, and their "numerous corpuscles, turned in various directions, some presenting nucleoli," are shown.

After the fibres have been hardened in alcohol or solution of osmic acid, they can readily be divided by means of needles into longitudinal filaments or *fibrils*, but even these may be still further divided, the finest of the filaments so obtained presenting the appearance of a series of minute dots. Under other modes of preparation, and especially by the action of hydrochloric acid, a transverse cleavage may take place, resulting in a series of minute discs (Bowman's discs). Whether either of these modes of division corresponds to a normal line of union of elementary parts has never yet been satisfactorily determined, some observers believing the *primitive fibrils* to constitute the true structural unit, and others holding that both fibrils and discs are alike accidental results of different means of preparation.

Under a high microscopic power numerous nuclei may be observed beneath the sarcolemma; they are more distinctly visible in fœtal muscle, but can also be traced in that of adult life by the addition of some weak acid. They frequently contain nucleoli, and there is little doubt that they are the nuclei of the cells from which the muscle was developed. Kölliker considers that each fibre arises from a single cell, by its longitudinal extension, and not, as some suppose, by the aggregation of several.

Various explanations of the transverse markings in striated muscle have from time to time been propounded, but none has hitherto

met with general acceptance. The theory advanced by Mr. Wilson, and first published in this work, is here reproduced in the same form that it has appeared in all the later editions.

"The ultimate fibril of animal life is cylindrical when isolated, and probably polyhedral from pressure when forming part of an ultimate fibre or fasciculus. It measures in diameter $\frac{1}{20000}$ of an inch, and is composed of a succession of cells connected by their flat surfaces. The cells are filled with a transparent substance, which may be termed *myoline*. The myoline differs in density in different cells, and from this circumstance bestows a peculiarity of character on certain of the cells. For example, when a fibril in its passive state is examined, there will be seen a series of dark oblong bodies separated by light spaces of equal length; now, the dark bodies are each composed of a pair of cells containing the densest form of myoline, and are hence highly refractive, while the transparent spaces are constituted by a pair of cells containing a more fluid myoline. When the fibrils are collected together so as to form an ultimate fibre or fasciculus, the appearance of the cell is altered: those which look dark in the single fibril, that is the most refractive, being ranged side by side, constitute the bright band; while the transparent cells of the single fibril are the shaded striæ of the fibre. When the ultimate fibril is very much stretched, the two highly refractive cells appear each to be double; while the transparent space is evidently composed of four cells."

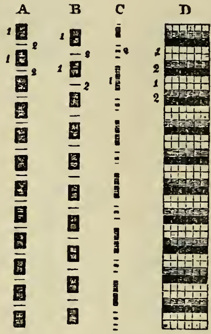


FIG. 39.—Structure of the ultimate muscular fibril and fibre of animal life. A. Ultimate muscular fibril in the state of partial contraction. B. The same in the state of ordinary relaxation. This fibril measured $\frac{1}{20000}$ of an inch in diameter. C. A similar fibril put upon the stretch, and measuring $\frac{1}{50000}$ of an inch in diameter. D. Plan of a portion of an ultimate fibre, showing the manner in which the transverse striæ are produced by the collocation of the fibrils.

Krause * believes that the fine line seen crossing the light stripe, and referred to above as the secondary stripe, indicates the existence of a delicate transverse partition springing from the sarcolemma, and dividing the interior of the muscle into a number of disc-like compartments built up one over the other. He also believes in the existence of a delicate lateral membrane, closing in the sides of the sarcous elements; the elementary fibril comes thus to be made up of a linear series of square boxes or "muscle caskets" united by their ends.

Dr. David Newman,† taking up the investigation at this point,

* Krause, "Über den Bau der quergestreiften Muskelfaser" (Zeitsch. für ration. Medicin, 1868, s. 265, und 1869, s. iii.).

† Newman, Journal of Anatomy and Physiology, vol. xiii. p. 549.

and accepting Krause's views as far as we have here explained them, has endeavoured to ascertain the nature of the contents of the caskets and the changes which take place in them during contraction. He finds that when the muscle is absolutely at rest neither the longitudinal nor transverse striation can be distinguished, but they appear during contraction, the longitudinal striæ being most marked when the muscle is stretched and contracted. He says: "The 'muscle caskets' are in the form of hollow cylinders united at their bases more firmly than at their sides; these cylinders contain a fluid—*muscle plasma*—which during a state of rest holds a certain quantity of fat in solution, so that the whole of their contents possess the power of double refraction. When, however, either the electrical or chemical condition of the plasma is altered, the plasma, first at the sides, then progressively towards the centre, precipitates its fat, and as this is precipitated it collects itself in the form of a flattened disc in the centre of the cylinder. The remaining plasma, freed from its fat, constitutes the light bands which are only singly refracting. The cylinder becomes by this change shortened in its length and increased in width; the centre of each casket bulges towards its neighbour, giving the fibril a varicose appearance, from which results the appearance of longitudinal striation. If these changes be now supposed to occur throughout all the cylinders of a muscle, it is evident that the muscle will contract, and at the same time increase in transverse measurement, without actual diminution in volume. That the broad dark bands are composed to a large extent of fatty matter may be demonstrated by placing a piece of living frog's muscle in 5 per cent. solution of acetic acid, when after a short time the dark bands will disappear, and small globules of fat take their place. In some specimens of frog's muscle this fat amounted to .523 per cent. of the weight of the muscle."

Striped muscular fibres usually neither divide nor anastomose, but an exception to this rule is found in the muscles of the tongue and of the heart, which do both. The fibres of the facial muscles also, where they are attached to the skin, frequently divide into branches.

Non-striated, plain, or involuntary muscular fibres (called also muscular fibres of organic life) consist of elongated, fusiform, nucleated cells, commonly pointed at their ends, and from mutual pressure polyhedral in transverse section. The nucleus is oval, and sometimes so elongated as to deserve the name of columnar; it contains an elaborate network of very fine fibrils. The body of the cell is granular, and presents traces of longitudinal striation; it has a fine sheath, probably elastic, and containing transverse linear thickenings, which here and there give the fibre a varicose appearance. The transverse lines are most distinct when the cell is contracted (Klein). The fusiform cells are united into little bundles or fasciculi by an adhesive interstitial substance, and the fasciculi, which are sometimes round and sometimes flat, are bound together into larger bundles by areolar tissue and fine elastic fibres;

the interspaces of the bundles being occupied by vessels and nerves, the former in great abundance.

The fasciculi are connected by their ends with fine tendinous fibres, by means of which they become attached to neighbouring parts.

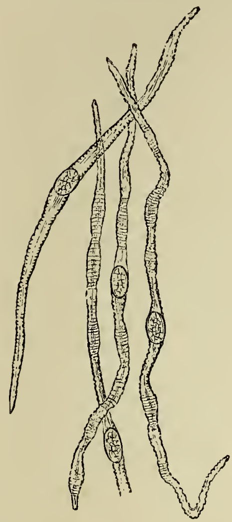


Fig. 40.—Non-striated muscular fibres from mesentery of newt; showing that each cell consists of a central bundle of fibres connected with the intra-nuclear network, and a sheath with annular thickenings.

Organic or smooth muscle is distributed abundantly in the animal frame, and is met with in the alimentary canal, from the middle of the œsophagus to the internal sphincter ani; in the posterior segment of the trachea, and in the bronchial tubes to their finest ramifications; in the excretory ducts of various glands, as Wharton's duct, the common bile duct, the calices and pelvis of the kidneys; in the capsule and trabeculæ of the spleen, the ureters, bladder, and urethra; on the testes, around the vasa deferentia and vesiculæ seminales, the prostate, Cowper's glands, and in the substance of the corpora cavernosa; in the Fallopian tubes, uterus, and vagina; in the mucous membrane; in the middle coat of arteries, veins, and lymphatic vessels; in the iris and ciliary muscle; and in the corium of the skin, particularly in the areola and nipples of the mammary glands, in the dartos of the scrotum, and around the hair follicles, and many of the sudoriferous and sebaceous ducts.

The heart, although involuntary in its action, is composed of striated muscular fibre; it presents, however, certain structural peculiarities which distinguish it from both classes of muscle; the description of these will be found along with the general account of the organ in the Part devoted to the description of the viscera.

NERVE TISSUE.

The nervous system consists of nerve centres and of rounded or flattened cords, called *nerves*, which connect the centres with each other, and bring them into relation with the surface of the body, and with the different organs. The brain and spinal cord constitute the great nervous centre, or cerebro-spinal axis, and the great majority of the nerves spring from this centre or are connected with it. There also exists a secondary system of nerves called *sympathetic*, the centres of which occur in the form of numerous minute masses named ganglia,

which are distributed chiefly in the thorax and abdomen, and are intimately connected with the nerves going to the organs contained in those cavities. The sympathetic and cerebro-spinal nerves have frequent communications with each other, which form complicated networks or *plexuses.*

The **nerve tissues** in the centres and peripheral nerves are readily separable into two forms, the white and the grey ; the former constitutes the greater portion of the interior of the brain, the outer part of the spinal cord, and all the nerves which spring from these ; the latter existing in the interior of the spinal cord, on the surface of the brain, in the interior of the brain near its base, and in the sympathetic and cerebro-spinal ganglia. The **structural elements** of the nervous system are also of two kinds, nerve fibres and nerve cells. The fibres form the channels of communication between the centres and the organs, and when gathered together into bundles form nerves ; the cells are restricted in their distribution to the nerve centres and certain of the organs of sense.

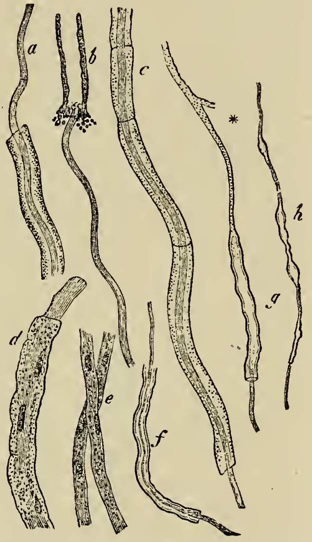


FIG. 41.—Nerve fibres of various kinds. *a.* Showing the axis cylinder and primitive sheath. *b.* Another, with axis cylinder, after treatment with bichromate of potash. *c.* A fibre, treated with collodium, showing the axis cylinder and primitive sheath. *d.* A non-medullated fibre, showing the axis cylinder and primitive sheath. *e.* A non-medullated fibre from the olfactory of the calf. *f, g, h.* Fine fibres from the brain with axis cylinders. The fibre *g* unites above with the process of a ganglion cell.

NERVE FIBRES are of two kinds—white or medullated, and grey or non-medullated.

The **white or medullated** nerve fibres form the white matter of the brain, spinal cord, and nerves. When examined immediately after removal from the body they seem to be structureless, and are bounded by a wavy outline. In a short time, however, their appearance changes, and they come to present a double boundary line ; the fibre now consists of three parts, an outer delicate, transparent covering, a central thread, firm and solid in consistence, and between these a substance which has a wavy or irregular margin, and often a nodulated aspect. The outer layer is called the *primitive sheath* (*sheath of Schwann*) ; it is so fine and transparent as to be difficult of demonstration, and, indeed, it is only when a break takes place in the substance of the fibre that it becomes visible ; it is elastic and apparently structureless, and has lying beneath it at regular intervals a number of minute nuclei.

The primitive sheath disappears when nerves enter the substance of the brain or spinal cord, and is also absent from many nerves in this peripheral distribution.

The pulpy substance which lies between the primitive sheath and the central thread is called the *medullary sheath* (white matter of Schwann). It is viscous, clear, transparent, and easily susceptible of coagulation, and is converted in its coagulated state into an opaque, granular, white substance. It is found to consist to a large extent of fatty matter, and, after nerves have been some time removed from the body, becomes irregular in outline, its margins become wrinkled, and portions of it assume the form of round or irregular nodules; these changes are presumably the result of a kind of coagulation.

The centre of the fibre is formed by a firmer and more homogeneous band called the *axis cylinder.* It is elastic, greyish in colour, has a very faint and indistinct boundary line, and is generally flattened or oval in transverse section; it is about one-third the thickness of the nerve fibre. It often presents traces of longitudinal striation, and may occasionally be split up into fine filaments, this taking place especially at the commencement and termination of a nerve; these filaments have been regarded by Max Schultze and others, as the ultimate structural elements of the nerve, and have hence been called *primitive fibrillæ.* The axis cylinder is distinguished from the other parts of the nerve fibre by its becoming deeply coloured, when a thin section of fresh nervous matter is placed in a solution of carminate of ammonia, while the primitive sheath becomes only faintly tinged, and the medullary sheath is totally unaffected by the reagent.

Nodes of Ranvier.—Medullated nerve fibres present breaks in the continuity of their structure at intervals of about $\frac{1}{25}$ of an inch. At these points the axis cylinder is continued uninterruptedly; the primitive sheath also passes over the breaks, but as the fibre is here smaller than elsewhere, the sheath is drawn inwards towards its centre. The medullary sheath is, however, completely interrupted, terminating by a rounded edge. The primitive sheath is separated from the axis cylinder by a small quantity of material of an albuminous character, and corresponding in its behaviour with reagents to the incellular substance which we have spoken of, as cementing together neighbouring cells. These breaks in the nerve fibre have been named from their discoverer the **Nodes of Ranvier.**

Non-medullated or Gelatinous Nerve Fibres are found in the great nerve centres as continuations of the medullated fibres; they also constitute the greater number of the fibres of the sympathetic, and the whole of the olfactory nerves in man. In the brain and spinal cord, they are often found to be connected with the processes of the multipolar nerve cells, and often serve to connect the medullated fibres with those cells. They are pale in colour, flattened, and bounded by single contour lines; they measure from $\frac{1}{6000}$ to $\frac{1}{8000}$ of an inch in diameter. In structure they are found to consist of a transparent, apparently homogeneous

sheath corresponding to the primitive sheath of the medullated fibres, beneath which are numerous oval nuclei. The interior of the fibre consists of a substance corresponding in every particular to the axis cylinder of medullated fibres, and made up of bundles of exceedingly fine primitive fibrillæ. Non-medullated fibres may thus be regarded as medullated fibres devoid of a medullary sheath.

FIG. 42.—Gelatinous nerve fibres from olfactory nerve.

NERVE CELLS.—These are found in the grey matter of the brain and spinal cord, and in the cerebro-spinal and sympathetic ganglia. They are of various shapes and sizes. Some in the grey matter of the cortex of the brain, in the posterior horn of the grey centre of the spinal cord, and in certain ganglia, are spheroidal, and of very small size. The majority of the nerve cells are, however, distinguished by possessing processes or "poles" by means of which they become connected with each other, and with the nerve fibres passing into the grey centres. A few of the cells possess only one process, and are called *unipolar*, others have two processes, and are called *bipolar*, but the majority have many processes which branch and form elaborate connections with neighbouring

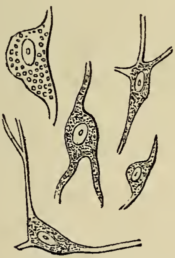


FIG. 43.—Cells from the substantia gelatinosa of the posterior horn of the spinal cord; magnified 350 times.

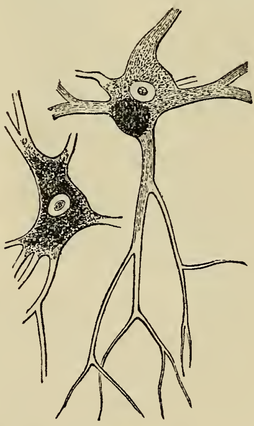


FIG. 44.—Large nerve cells, with branching processes, from the anterior cornu of the spinal cord. The pigment granules are collected into a mass in one of the cells, but are more generally distributed in the other. The cells measure between $\frac{1}{400}$ and $\frac{1}{200}$ of an inch in diameter; and their nuclei $\frac{1}{2500}$ to $\frac{1}{1500}$.

cells and nerve fibres, they are named *multipolar* cells. Many of the nerve cells found in the surface grey matter of the brain are

triangular in shape, having their bases directed towards the centre of the brain, and their apices towards the free surface, from their angles they give off fine processes. Nerve cells vary in size from $\frac{1}{200}$ to $\frac{1}{6000}$ of an inch in width, they have each one or more clear transparent nuclei, in the centre of each of which a nucleolus is visible. The cells' contents are often granular, of a light brown or greyish colour, and present traces of striation, such as we noticed in the axis cylinder of medullated nerve fibres; not unfrequently they contain deposits of brown pigment. They are undoubtedly

FIG. 45.—Multipolar ganglion cells from the brain. 1. A cell, one of whose processes (*a*) becomes the axis cylinder of a nerve fibre (*b*). 2. A cell (*a*) connected with another (*b*) by means of a commissure (*c*). 3. Diagram of three cells (*a*) connected by means of commissures (*b*), and running into fibres (*c*). 4. A multipolar cell containing black pigment.

protoplasmic. No distinct limiting membrane or cell wall has been ascertained to exist, but each cell is lodged in a kind of capsule composed of fine connective tissue, and lined by a delicate layer of flattened epithelial cells. The cell processes are composed of protoplasm of the same nature as the cell itself, they also present traces of fibrillation, and are likewise destitute of a limiting membrane. One or more processes of each nerve cell may be traced into a nerve fibre, becoming continuous with the axis cylinder of the fibre; other

processes become continuous with the "poles" of neighbouring cells. From the fact that nerve cells were first discovered in ganglia, they are often called "ganglion cells," the true ganglion cell, however, often differs from the cells above described, in respect that the primitive sheath of the nerve is continued as a covering over the cell, and in some instances the medullary sheath also may be traced as a thin coating over its exterior.

The proper substance of the nervous centres (nerve fibres and nerve cells) is supported by a peculiar modification of connective tissue, described by Virchow under the name of *neuroglia.* This bears a close resemblance to the *reticular tissue*, described on a previous page, consisting of a reticulum formed by the intercommunication of branched connective-tissue corpuscles. Besides this, there exists a finely granular matrix, in which the nerve cells are embedded.

GANGLIA.—In its widest signification a ganglion is a nervous centre, whether found in the interior of the brain or spinal cord, or existing in an isolated position, remote from those great aggregations of nerve matter; in a more restricted sense it is limited to those small secondary centres found in large numbers throughout the sympathetic system, in connection with the roots of the spinal nerves, and on the trunks, or connected with some of the branches of the cerebral nerves. Ganglia have a fibrous covering, continuous with the sheath of the nerves entering and leaving them; from this capsule processes are sent into the interior of the ganglion, dividing it into compartments. The interior of the ganglion is of a greyish colour, and consists of nerve cells and nerve fibres, supported by connective tissue. The nerve cells are round, oval, or multipolar, and are covered by a continuation of the primitive sheath of the nerves, and sometimes also by the medullary sheath. Some of the nerve fibres pass through the ganglion without becoming connected with the cells, others terminate in the branches of the multipolar cells, their axis cylinder becoming continuous with the protoplasm of the cell process. Beale believes that every ganglion cell is connected with

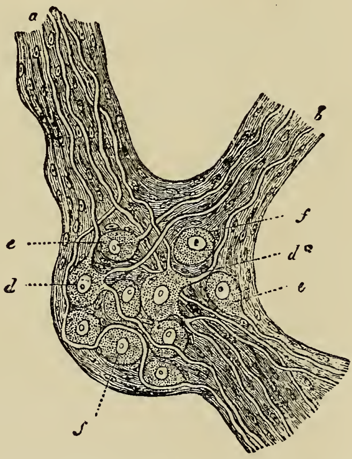


Fig. 46.—Sketch of a sympathetic ganglion. *a*, *b*, *c*. Nervous trunks. *d*. Multipolar cells. *d**. Some of the latter with a dividing nerve fibre. *e*, unipolar, and *f*, apolar cells.

at least two nerve fibres, one of which is straight, and passes directly to the centre of the cell, the other winds spirally round the first, and is traceable for some distance on the outer surface of the cell. According to Arnold the central fibre is connected with the nucleus of the cell and the spiral fibre with the nucleolus. The two fibres on leaving the cell run in opposite direction in the nerve with which the ganglion is connected.

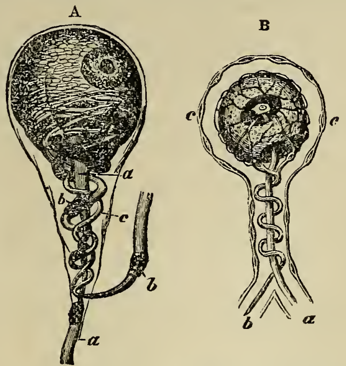


Fig. 47.—Structure of ganglionic nerve cell. A. According to Beale. B. According to Arnold. *a*. Central fibre. *b*. Spiral fibre. *c*. Capsule of ganglion.

A commissure is a mass of fibrous nerve matter which acts as a link of communication between two nerve centres.

A nerve is a rounded or flattened cord of nerve fibres which forms the channel of connection between the nerve centres and all the parts of the body. The nerve cords are surrounded by a strong sheath of fibrous membrane, which not only preserves their rounded form, but forms septa which pass into the interior of the cord, subdividing it into a number of strands or *funiculi*. In many nerves this subdivision is so perfect that, if cut across in the fresh state, and squeezed, the appearance is presented of a circular disc from which white pulp exudes from little apertures. The membrane which isolates these funiculi is sometimes called the *neurilemma;* it serves to support the delicate tissue of which the nerve tubes are composed, and also as a channel along which the blood-vessels reach the interior of the cord.

In many cerebro-spinal nerves the nerve sheath can be separated into two layers, the outer continuous with the dura mater and the inner with the arachnoid, the former has been named the *epineurium*, and the latter the *perineurium*. Between these layers there is a small space continuous with the subdural space of the brain and spinal cord.

Branching of Nerves.—A branch of a nerve consists of several funiculi which leave the parent trunk and become invested with a neurilemma derived from its sheath.

Inosculation or Communication.—Nerves frequently form junctions of a portion of their substance so as to become complex in structure, but in such cases the individual nerve fibres do not as a rule communicate with each other, but remain separated by their medullary and primitive sheaths. In the nervous centres, however, in the peripheral distribution of the nerves, and, in rare instances, in their trunks, the fibres themselves branch and form communica-

tions, so as to produce a true anastomosis. Nerve tubules by their tubular membrane or medullary sheath are insulated throughout their whole course.

Plexus.—A plexus is an intricate intercommunication between the funiculi of adjacent nerves.

Origin.—The *apparent* origin of a nerve is where it becomes connected with the surface of a nerve centre. The *real* origin is where its tubules terminate in the substance of its nerve centre—often far away from where it plunges into the nerve surface. It is very difficult to trace accurately the deeper connections of the extremities of nerve tubules, but as in many instances they have been observed to be directly connected with multipolar cells, the opinion is becoming general that all nerve fibres have a central connection with a nerve cell.

NERVE TERMINATIONS.—Nerve fibres, whether of the medullated or non-medullated variety, when they approach their termination, freely branch, and form numerous communications among themselves, the medullated fibres lose their medullary sheath, and become indistinguishable from the non-medullated kind. The axis cylinder takes part in the branching of the fibres, and becomes split up into very fine threads, consisting of only a few elementary fibrils. The primitive sheath is continued as a covering to the divided fibres, for some distance after they have lost their medullary sheath, but at length becomes also lost; and the fine pale fibrils which form the termination of the nerve may then be traced as faint lines having a wavy course, and marked at short intervals by minute nuclei.

Sensory or afferent nerves and **motor or efferent** nerves have very different modes of termination, and require therefore a separate description.

Sensory Nerve Endings.—Sensory nerves terminate either in epithelial cells, as in the cornea and skin, or by special terminal organs, some of which fall to be described here, while others will come under consideration in the description of the organs of sense to which they belong. We shall in this place speak only of the *Pacinian corpuscles*, and the *end bulbs* of Krause, leaving the *rods* and *cones* of the retina, the *cells of Corti*, and *acoustic filaments* of the internal ear, the *taste buds* of the tongue, the *olfactory cells* of the nose, and the *tactile corpuscles* of the skin to be discussed in the section on the organs of sense.

The Pacinian or Vater's Corpuscles are small oval or pyriform masses, varying in size from half a line to three lines in length, situated on the peripheral extremities of the nerve fibres, chiefly in the palm of the hand and sole of the foot, but also found in other parts, as the bulb of the urethra, on the intercostal nerves, on the cutaneous nerves of the neck, arm, and leg, and dorsum of the hand and foot, infraorbital nerve, and on the nerves of the periosteum, and those distributed to joints. It has been calculated that in the palm of the hand and palmar surface of the fingers there are six

hundred of these bodies, and at the extremities of the fingers they are especially numerous. They are situated for the most part in the subcutaneous areolar tissue, are clear, transparent, and glistening in appearance, and traversed internally with white streaks. In structure a Pacinian body is composed of from twenty to sixty concentric layers or capsules of areolar tissue, separated by spaces containing a serous fluid, and having a central cavity also filled with serous fluid, which contains the free extremity of a nerve fibre, divested of its sheath and medulla and reduced to the condition of an axis cylinder. The intercapsular spaces are wider between the external than the

FIG. 48.—Portion of a digital nerve, showing the disposition of the Pacinian corpuscles.

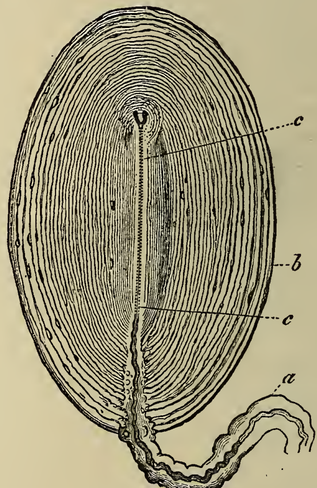


FIG. 49.—*Pacinian* corpuscle from the mesentery of a cat. *a.* A nerve forming the stalk. *b.* The system of capsules. *c.* Axial canal or internal bulb, within which the axis cylinder ends forked.

internal layers, and each capsule is lined by a single layer of squamous epithelial cells; neighbouring capsules are often branched and connected with each other by fibres. The central stalk of the corpuscle consists of the medullated nerve fibre entering it, and the sheath of the nerves may be traced into the outer layers of the capsule. The axis cylinder included within the central cavity ends in a small rounded tubercle, and not unfrequently is bifid or even trifid.

The **end bulbs of Krause** have been ascertained to exist in the sclerotic conjunctiva, the mucous membrane of the floor of the mouth,

the soft palate and tongue, the lips, and in the skin of the glans penis and glans clitoridis. They are usually spheroidal or oval in shape, and measure about $\frac{1}{600}$ of an inch in diameter. They consist of a capsule of connective tissue containing a soft substance which is transparent and apparently granular, and has embedded in it numerous oval nuclei. A medullated nerve fibre enters its under surface, and as it passes in, generally loses its medullary sheath; the axis cylinder may be traced into the central matrix, where it terminates by dividing into two or more branches. They thus closely resemble the Pacinian corpuscles. The end bulbs which pass to the genital organs differ in some respects from those just described, and have been named "genital nerve corpuscles;" they are characterised by the existence of numerous constrictions which give them a mulberry-like appearance.

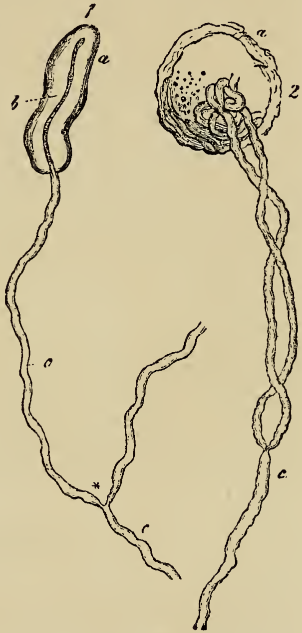


Fig. 50.—End bulbs. 1. From the conjunctiva of a calf. 2. From that of a human being. *a*. Bulb. *c*. Nerve fibre ending in (1) an axis cylinder (*b*).

Motor Nerve Endings. — Of these there are two varieties; namely, those passing to striated muscle, and those distributed to the non-striated. The former have received the name of *motorial end plates.* The nerves passing to a voluntary muscle retain their medullary sheath, and primitive sheath, till they reach the sarcolemma, when the former ceases, and the latter becomes continuous with the sarcolemma. The axis cylinder pierces the sarcolemma and expands beneath it, so as to produce a prominence (*nerve eminence*), often divided into lobes, and containing many clear oval nuclei. In unstriped or involuntary muscle the nerve fibres are arranged in very fine plexuses over the surface of the muscle cells, and some histologists state that the terminal filaments can be traced into the nucleus or nucleolus of the cell.

SYMPATHETIC NERVE.—The sympathetic or ganglionic nerve, or system of organic nerves, has received its various designations from its numberless communications and anastomoses, from its composition of a series of ganglia, and from its distribution chiefly to the viscera of the body. It consists of a cord of moderate thickness, which extends from the head to the coccyx, lying by the side of the vertebral column, of a series of ganglia, some of which are fusiform

and others flattened and multangular, of short branches of communication from the spinal nerves, and peripheral branches, which for the most part follow the trunks of arteries, and are distributed to the viscera after uniting with ganglia in their course, or forming smaller ganglia in their distribution. The elementary constituents of the ganglionic nerve are: medullated nerve fibres of every degree of magnitude from coarse to fine, non-medullated or ganglionic nerves, and nerve cells. The medullated nerve fibres are derived from the anterior and posterior roots of the spinal nerves, chiefly from the latter; entering the ganglion, they divide into an ascending and descending fasciculus, which pass upwards and downwards along the main trunk of the nerve, or pass off with the larger branches in company with ganglionic nerves. The non-medullated fibres originate in the multipolar cells of the sympathetic ganglia.

The branches of the sympathetic nerve present some difference of colour, having reference to the greater or less preponderance of the white or ganglionic fibres; thus the splanchnic nerves are white, the mesenteric branches greyish-white; and the filaments ramifying on the branches of the carotid arteries reddish-grey and soft (nervi subrufi, molles); the cardiac branches and pelvic plexuses are also grey and soft.

In their peripheral terminations the branches of the sympathetic nerve present numerous minute, almost microscopic ganglia, which are especially remarkable on the carotid arteries, in the pharyngeal plexus, upon the heart, around the root and in the substance of the lungs, upon the supra-renal capsule, on the lymphatic glands, on the posterior wall of the urinary bladder, and occasionally in the kidneys. In structure these ganglia are identical with the larger ganglia.

BLOOD-VESSELS.

The blood is distributed throughout the body by means of a series of tubes, which proceed from the heart, ramify through all the organs and tissues, and again return to the heart; thus the blood in its course constantly returns to the centre from whence it was sent forth, and it is this which constitutes the *circulation*. The tubes which carry the blood are called blood-vessels; they are of three kinds—namely, those which convey the blood from the heart to the tissues, **arteries**; those which run through the tissues and organs, **capillaries**; and those by means of which the blood is returned from the tissues to the heart, **veins**.

The artery proceeding from the left ventricle of the heart contains the pure or arterial blood, which is distributed throughout the entire system, and constitutes with its returning veins the *greater* or *systemic circulation*. That which emanates from the right ventricle conveys the impure blood to the lungs; and with its corresponding veins establishes the *lesser* or *pulmonary circulation*.

ARTERIES.

do not have valves

The **arteries** are the cylindrical tubes which convey the blood from the ventricles of the heart to every part of the body. They are dense in structure, and preserve for the most part the cylindrical form when emptied of their blood, which is their condition after death: hence they were considered by the ancients as the vessels for the transmission of the vital spirits,* and were therefore named arteries (ἀὴρ τηρεῖν, to contain air).

The whole of the arteries of the systemic circulation proceed from a single trunk, named the *aorta*, from which they are given off as branches, and divide and subdivide to their ultimate ramifications, constituting the great arterial tree which pervades by its minute subdivisions every part of the animal frame. The mode in which the division into branches takes place is deserving of remark. From the aorta the branches for the most part pass off at right angles, as if for the purpose of checking the impetus with which the blood would otherwise rush along their cylinders from the main trunk; but in the limbs a very different arrangement exists; the branches are given off from the principal artery at an acute angle, so that no impediment may be offered to the free circulation of the vital fluid. The division of arteries is usually dichotomous, as of the aorta into the two common iliacs, common carotid into the external and internal, &c.; but in some few instances a short trunk divides suddenly into several branches which proceed in different directions: this mode of division is termed *axis*, as the thyroid and cœliac axis.

In the division of an artery into two branches, it is observed that the combined area of the two branches is somewhat greater than that of the single trunk; and if the combined area of all the branches at the periphery of the body were compared with that of the aorta, it would be seen that the blood, in passing from the aorta into the numerous distributing branches, was flowing through a conical space, of which the apex might be represented by the aorta, and the base by the surface of the body. The advantage of this provision in facilitating the circulation is sufficiently obvious; for the increased channel which is thus provided for the current of the blood, serves to compensate for the retarding influence of friction, resulting from the distance of the heart and the division of the vessels.

Communications between arteries are free and numerous, and increase in frequency with the diminution in size of the branches; so that, through the medium of the minute ramifications, the entire body may be considered as one uninterrupted circle of *inosculations* or *anastomoses* (ἀνὰ, between, στόμα, mouth). This increase in the frequency of anastomosis in the smaller branches is a provision for counteracting the greater liability to impediment existing in them than in the larger branches. Where freedom of circulation is of vital importance, this communication of the arteries is very remark-

* To Galen is due the honour of the discovery that arteries contained blood, and not air.

able, as in the circle of Willis in the cranium, or in the distribution of the arteries of the heart. It is also strikingly seen in situations where obstruction is most likely to occur, as in the distribution to the alimentary canal, around joints, or in the hand and foot. Upon this free communication existing everywhere between arterial branches is founded the principle of cure by the ligature of large arteries; the ramifications of the branches given off from the artery above the ligature inosculate with those which proceed from the trunk of the vessel below the ligature; these anastomosing branches enlarge and constitute a *collateral circulation*, in which several large branches perform the office of the single obliterated trunk.

Structure of Arteries.—Arteries are composed of three coats, *external*, *middle*, and *internal*.

The **external coat** (*tunica adventitia*) is firm and strong; it is thin in the large arteries, but thicker than the middle coat in arteries of small and medium size, and is composed of white fibrous and elastic tissue. The white fibres are arranged in close bundles, which run for the most part diagonally or obliquely across the vessel; they form by their inter-communication a firm felted membrane, with minute interspaces, in which lie numerous branched connective-tissue corpuscles. Among the white fibres a few elastic fibres are found; these are most numerous in the inner layers (that is to say, near the middle coat), and are arranged longitudinally. The interlacement of the fibres is closest in the inner layers, and becomes looser as we approach the outer surface of the vessel. Longitudinal bands of unstriped muscular fibre have been described as existing in the outer coat of many of the larger arteries, such as the splenic, renal, mesenteric, axillary, popliteal, and femoral.

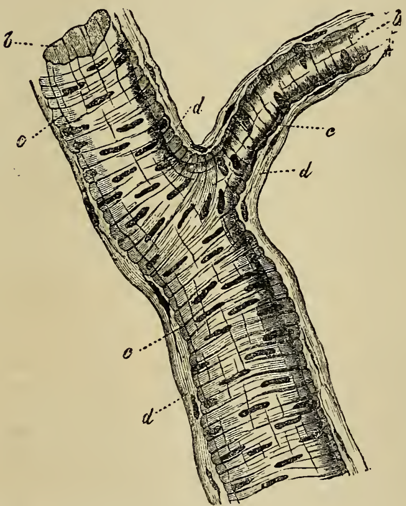


FIG. 51.—A small artery. At *b*, the homogeneous internal layer; *c*, middle tunic formed of contractile fibre cells; *d*, the external connective-tissue tunic.

The **middle coat** (*tunica media*) is in all arteries the thickest and most important. It is composed of many layers of smooth muscular fibres, with, in the larger arteries, the addition of elastic tissue, and a small quantity of white fibrous tissue; these structures are almost

entirely arranged transversely. This coat is very brittle, and hence is easily cut through when a ligature is applied. The *smooth muscular tissue* is almost the only component structure of the middle coat of small arteries; in which there are two or three laminæ, the fibres, about $\frac{1}{3000}$ of an inch in diameter, and $\frac{1}{300}$ to $\frac{1}{200}$ of an inch long, being arranged in rings; in smaller arteries there is but one muscular lamina, the elements of the fibres being shorter, and in proportion as the arteries are more minute, becoming reduced to the earliest developmental form — namely, short elliptic cells with oblong nuclei; ultimately they are completely lost. In arteries of medium size, elastic fibres are superadded to the muscular fibres, the latter predominating for a while, and in the large arteries the smooth muscular fibres are diminished in number and importance, and are scattered among the layers of elastic tissue, of which the middle coat of large arteries is principally composed.

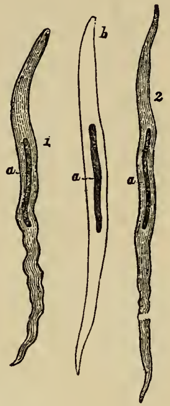


FIG. 52. — Smooth muscular fibre cells from the middle coat of the artery. 1. From the popliteal. 2. From a twig of the anterior tibial, half a line in diameter. *a,a,a.* Elongated or rod-like nucleus. The middle cell (marked *b*) has been rendered transparent by immersion in vinegar. Magnified 350 times.

The *elastic tissue* is absent altogether in the middle coat of small arteries, but makes its appearance in arteries of medium size as fine fibres disposed in a network of wide meshes. In the larger kind of medium-sized arteries, the elastic network is mingled with areolar tissue, and a tendency to the alternation of these tissues begins to be apparent. While thus encroaching as it were on the structure of the middle coat of arteries, the elastic tissue presents a corresponding series of transitional forms; at first it exists as fine fibres disposed singly or in a fine network with open meshes; then the fibres become larger and the meshes closer, and interlaced so as to form a fibrous membrane with narrow meshes; next, by the increase of breadth of their fibres and their intimate union or fusion, a homogeneous membrane is formed, in which the meshes appear as simple perforations (fenestrated membrane). In medium-sized arteries the elastic tissue forms a single layer lying exteriorly to the muscular fibres; in the largest arteries of this class it is mingled with areolar tissue, and exhibits a tendency to become laminated, the laminæ alternating with similar layers of

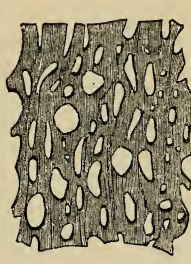


FIG. 53.—Elastic membrane of the fenestrated kind, from the middle coat of the carotid artery of the horse. Magnified 350 times.

areolar tissue. In the large arteries this is the common character of the middle coat; the elastic tissue is laminated, and between the laminæ are strata of areolar and muscular tissue. The presence of elastic tissue as a chief constituent of the middle coat of arteries gives them a yellow colour, while those arteries in which the muscular tissue is abundant have a reddish tint. In the aorta, the laminæ of the middle coat are forty or fifty in number. In the ascending aorta the muscle cells in the inner part of the middle coat are arranged longitudinally or obliquely, and are very much branched or forked; this branching is also observed in the transversely arranged muscle cells of most of the larger arteries.

The **internal coat** (*tunica intima*) is the thinnest of the three, and easily broken in the transverse direction; it is composed of three layers, an internal layer or *epithelium*, a *subepithelial* layer, and an external *elastic membrane*, which is either homogeneous or made up of elastic elements, disposed in a longitudinal direction. The *internal epithelial* layer is formed by a single layer of flattened cells, very thin, polygonal or elliptical in shape, and having transparent oval nuclei; their outlines can be made evident by pencilling the inner surface of the artery with a solution of nitrate of silver. The *subepithelial* layer is absent from the smallest arteries, but is distinguishable in all those of medium and large size in the form of longitudinal bundles of fibrous connective tissue, between which are numerous anastomosing branched connective-tissue cells. The *elastic layer* is a thin, homogeneous membrane of the fenestrated kind, perforated with minute oblong openings having a direction parallel with the axis of the vessel. It is folded into longitudinal rugæ when the vessel is empty, and becomes extremely delicate, and is finally lost in the minute vessels. Exteriorly this layer assumes a reticulated character, and is made up of a longitudinal network of elastic fibres.

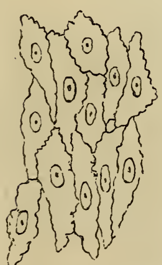


Fig. 54. — Epithelial cells lining an artery.

In taking a summary survey of the constituent tissues of the three coats of arteries in their order of succession from without inwards, it will be seen that the external coat consists of areolar and elastic tissue; the middle coat of smooth muscular fibre, areolar and elastic tissue; and the internal coat of elastic tissue and epithelium.

The arteries in their distribution through the body are included in a loose areolo-fibrous investment which separates them from surrounding tissues, and is called a *sheath*. Around the principal vessels the sheath is an important structure; it is composed of areolar tissue, intermingled with aponeurotic fibres, and is continuous with the fasciæ of the region in which the arteries are situated, as with the thoracic and cervical fascia in the neck, transversalis and iliac fascia, fascia lata in the thigh, &c. The sheath of the arteries contains also their accompanying veins, and sometimes a nerve.

The coats of arteries are supplied with blood like other organs of the body; their vessels proceed from the neighbouring small branches, and are named *vasa vasorum*. The vasa vasorum or vasa nutritia are distributed in the external coat, some few making their way among the external layers of the middle coat. They are met with even on the smallest arteries, and form a rich capillary network with rounded meshes. The small veins which return the blood from the capillaries, open into the companion veins of the artery. The *nerves*, like the vasa vasorum, are found only in the external coat, and are wanting altogether in many arteries, as in those of the cerebral and spinal substance, the choroid membrane of the ovum, the placenta, and also in the arteries of some muscles, glands, and membranes.

CAPILLARIES.

The arteries do not terminate directly in veins; but in an intermediate system of vessels which, from their minute size (about $\frac{1}{3000}$ of an inch in diameter), are termed *capillaries* (*capillus*, a hair). The capillaries constitute a microscopic network, which is distributed through nearly every part of the body, so as to render it impossible to introduce the smallest needle-point beneath the skin without wounding several of these fine vessels. It is through the medium of the capillaries that all the phenomena of nutrition and secretion are performed. They are remarkable for their uniformity of diameter, and for the constant divisions and communications which take place between them, without any alteration of size. They communicate on the one hand with the terminal branches of the arteries, and on the other with the minute radicles of the veins. In the maternal part of the placenta and in the erectile organs (as the corpus cavernosum penis), the arteries empty into lacunar spaces, from which the veins gather up the blood, without the intervention of capillaries; and an arrangement somewhat similar is also found in the spleen. Sucquet and Hoyer assert that in some parts the small arteries pass directly into small veins, so that the blood does not enter the capillary system.

Structure of Capillaries.—The capillaries are the smallest and simplest of the blood-vessels, their wall being formed by a single layer of flattened epithelial cells, the edges of which can be brought into view by pencilling the surface with nitrate of silver. The cells are irregular in shape, being often pointed at their extremities and sinuous at their edges. They are united together by an albuminous cementing substance, and are connected externally with the processes of the connective-tissue corpuscles of the neighbouring tissues (Klein). During inflammation, the connecting cement of the cells often gives way so as to leave pores or *stomata*, through which the white corpuscles of the blood (and occasionally the red ones) pass. In certain parts the capillaries have, in addition to their epithelial lining, an outer coat, which is a network of branched connective-tissue cells.

Although capillaries are, as stated above, remarkable for their uniform size in any particular organ, they differ in this respect in different localities, being smallest in the brain and lung, and largest in the marrow of bones; they are small also in muscle and large in skin and mucous membrane. They differ greatly in the size and arrangement of the meshes which they form, and consequently in the amount of blood which they supply to the tissues, the network being very close in the lungs and choroid coat of the eye, and very wide in ligaments, tendons, and similar structures.

Fig. 55.—Transition of a minute artery into capillary vessels—from the brain. 1. Minute artery. 2. Transitional capillary. 3. Coarse capillary with thick coat, represented by a double contour line. 4. Fine capillary, with single contour. The nuclei are seen widely scattered in 4 and 3; more closely congregated in 2; and still more so in 1. *a*. The transverse elongated nuclei of muscular cells; the muscular coat of the artery.

VEINS. have valves

The veins are the vessels which return the blood to the auricles of the heart, after it has been circulated by the arteries through the various tissues of the body. They are much thinner in structure than the arteries, so that when emptied of their blood they become flattened and collapsed. The veins of the systemic circulation convey the dark-coloured and impure or *venous blood* from the capillary system to the right auricle of the heart, and they are found after death to be more or less distended with that fluid. The veins of the pulmonary circulation resemble the arteries of the systemic circulation in containing during life the pure or arterial blood, which they transmit from the capillaries of the lungs to the left auricle.

The veins commence by minute radicles in the capillaries which are everywhere distributed through the textures of the body, and converge to constitute larger and larger branches, till they terminate in the main trunks which convey the venous blood directly to the heart. In diameter they are larger than the arteries, and, like those vessels, their combined areæ would constitute a hollow cone, whereof the apex is placed at the heart, and the base at the surface of the body. It follows from this arrangement, that the blood in returning to the heart is passing from a larger into a smaller channel, and therefore that it increases in rapidity during its course.

Valves in veins of leg disappear in early youth mostly

Veins admit of division into superficial and deep.

The *Superficial veins* return the blood from the integument and superficial structures, and take their course between the layers of the superficial fascia; they then pierce the deep fascia in the most convenient and protected situations, and terminate in the deep veins. They are unaccompanied by arteries, and are the vessels usually selected for venesection.

The *Deep veins* are situated among the deeper structures of the body, and generally in relation with the arteries; in the limbs they are enclosed in the same sheath with those vessels, and they return the venous blood from the capillaries of the deep tissues. In company with all the smaller, and also with the secondary arteries, as the brachial, radial, and ulnar in the upper, and the tibial and peroneal in the lower extremity, there are two veins, placed one at each side of the artery, and named *venæ comites.* The larger arteries, as the axillary, subclavian, carotid, popliteal, femoral, are accompanied by a single venous trunk; and certain veins, such as those of the cranium, spinal canal, liver, and larger veins of bones, run apart from arteries.

The communications between veins are more frequent than those of arteries, and they take place between the larger as well as the smaller vessels; the venæ comites communicate with each other in their course by means of short transverse branches which pass across from one to the other. The office of these inosculations is very apparent, as tending to obviate the obstructions to which veins are particularly liable from the thinness of their coats, and from their inability to overcome much impediment by the force of their current.

Structure of Veins.—Veins closely resemble arteries in their structure, and like them are formed of three coats—*external* or *tunica adventitia*, *middle* or *tunica media*, and *internal* or *tunica intima.* It will be sufficient if we here indicate the particulars in which these several coats differ from those corresponding to them in arteries.

External Coat.—This is thick in proportion to the other coats, and is composed of longitudinal and oblique bands of fibrous tissue, with some elastic fibres; the interstices between the fibres lodge ramified connective-tissue corpuscles. In certain veins, as the inferior vena cava, renal, azygos, and external iliac veins, this coat contains a thin layer of unstriped muscular tissue.

Middle Coat.—The transverse muscular fibres which distinguish this coat in both arteries and veins are in the latter very thin; they never form continuous layers, and are never separated from each other by distinct elastic membranes as in the arteries, the intervening substance in veins being usually white fibrous tissue.

Inner Coat.—This coat is firmer than the inner coat of arteries, and can be stripped off without breaking; it consists of an epithelial layer, a subepithelial layer of ramified cells, and an elastic layer, either forming fenestrated membrane or existing simply as a closely areolated longitudinal network of coarse and fine elastic fibres.

Variations in the Structure of Veins.—The middle coat is wanting in the hepatic part of the vena cava and hepatic veins; it is most developed in the splenic and portal veins, and in those of the gravid uterus. The superior and inferior vena cava and pulmonary veins as they enter the heart receive a covering of striped muscular fibres, continued on to them from that organ. Muscular tissue is absent from the veins of the maternal part of the placenta, the jugular and subclavian veins, the sinuses of the dura mater, the veins of bones and muscle, and the spaces in the substance of the corpora cavernosa of the penis.

The **Valves of Veins** are composed of a thin stratum of areolar tissue mingled with fine elastic fibres, and a small quantity of unstriped muscular tissue; and coated on the two surfaces with the epithelial lining of the vessel. The segments or flaps of the valves of veins are semilunar in form, and arranged in pairs, one upon either side of the vessel; in some instances there is but a single flap, which has a spiral direction, and occasionally there are three. The free border of the valvular flaps is concave, and directed forwards, so that while the current of blood is permitted to flow freely towards the heart, the valves are distended, and the current intercepted, if the stream become retrograde in its course. On the cardiac side of each valve the vein is expanded into two pouches (sinuses), corresponding with the flaps of the valves, which give to the distended or injected vein a knotted appearance. The valves are most numerous in the veins of the extremities, particularly in the deeper veins, and they are generally absent in the very small veins, and in the veins of the viscera, as in the portal and cerebral veins, those of the liver, kidney, and uterus; they are also absent in the large trunks, as in the venæ cavæ, venæ azygos, innominatæ, pulmonary, and iliac veins. The trunk and branches of the umbilical vein are also devoid of valves.

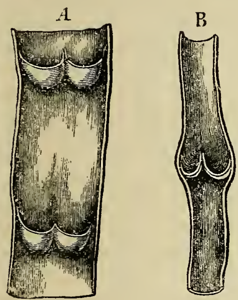


FIG. 56.—A. Part of a vein laid open, with two pairs of valves. B. Longitudinal section of a vein, showing the valves closed.

Sinuses are venous channels, excavated in the structure of an organ, and lined by the internal coat of the veins; of this structure are the sinuses of the dura mater, whose external covering is the fibrous tissue of the membrane. The external investment of the sinuses of the uterus is the tissue of that organ; and that of the bones, the lining membrane of the cells and canals.

Veins, like arteries, are supplied with nutritious vessels, the vasa vasorum; their nervous filaments, few in number and of small size, are derived from the sympathetic and spinal system; they have been chiefly found on the larger veins; as, the venæ cavæ, iliacs, crural, jugular, vertebral, and sinuses of the dura mater.

LYMPHATICS.

Lymphatic vessels form a secondary vascular system and serve two important purposes, namely, to convey into the blood the products of intestinal digestion, and to return to the blood materials which having been once used do not require to be excreted, but may, after undergoing change or elaboration in the lymphatic vessels and glands, be again used for the building up of tissues. The vessels employed for the first of these purposes are called *lacteals*, from the milky fluid they convey ; the rest of the vessels are called *lymphatics*, from the fluid contained being clear and transparent (*lympha*, water). These two kinds of vessels do not differ structurally from each other.

The lymphatic system consists of three parts, *vessels*, *capillaries*, and *glands*.

Lymphatic vessels are of two kinds — large vessels, as the thoracic duct and its tributaries ; and small vessels, such as are found throughout the body generally. Both kinds possess a great number of valves placed at very short distances from each other, so that when a lymphatic vessel is inflated it presents a beaded appearance. The valves are almost identical in structure and arrangement with those described in connection with veins, consisting of one or two semilunar folds formed by the lining membrane of the vessel.

The **large vessels** correspond in structure to veins, and have three coats of extreme thinness ; the outer formed of delicate fibrous tissue, the middle of striped muscular fibres, and the inner of elastic tissue supporting a single layer of nucleated epithelial cells, of elongated form and with sinuous edges.

The **small lymphatics** are very numerous, being found in every part of the body, in every organ, and probably existing in every tissue. They are much more numerous than the veins, but are of microscopic size ; they form, by their communications, complicated plexuses, the meshes of which are often exceedingly close. Their walls are formed by a single layer of flattened epithelial cells with sinuous edges and nuclei which are not in the centre of the cells ; their tubular shape and the existence of valves serve to distinguish them from the lymphatic capillaries.

Lymphatic Capillaries.—These are often larger than the smallest trunks, but are distinguished from them by the extreme irregularity of their shape and absence of valves. They vary greatly in their arrangement in different parts, sometimes ensheathing the blood-vessels, at others forming irregular lacunar cavities, or, yet again, enclosing the bundles of fibrous tissue in a tendon, and forming for them a delicate sheath. In whatever form they exist, they may be identified by pencilling the tissue with a solution of nitrate of silver, when the epithelial cells are made evident by the coloration of the intercellular cementing substance. The wall is formed by a single layer of cells, which differ from those lining the smallest lymphatic vessels by being shorter, and having more sinuous outlines.

Many lymphatic capillaries open into a system of lacunæ, connected with each other by minute canals (the *lymph-canalicular system* of Recklinghausen), the lacunæ lying in an albuminous ground substance, and lodging ramified cells or connective-tissue corpuscles. The contained cells constitute a sort of lining on one side of the lacuna, and are continuous with the epithelial cells of the lymphatic capillary with which the lacuna is connected. The lymph-canalicular system is almost the only representative of the lymphatics in the cornea, the grey and white matter of the brain and spinal cord, and in cartilage. In tendon, fasciæ, muscle of both kinds, and nerves, the lymphatics are found as continuous clefts or longitudinal spaces between the connective-tissue bundles or the proper fibres of the tissue. In areolar tissue they form the areolæ or interspaces which we have described on a previous page as characterising that tissue; and in the nervous centres they form spaces or sheaths around the blood-vessels, which have been named *perivascular lymph spaces.* The lymphatics of serous membranes are very numerous, and have a complicated arrangement which cannot here be fully described; the most important features are, first, that there are frequent invaginations of the blood-vessels, either by lymphatic tubes or by an intercommunicating system of lymph sinuses lined with epithelium; and, second, that the capillaries communicate with the surface of the serous membrane by means of openings called *stomata*, which are bordered by germinating epithelium differing in character from the cells which form the surface of the membrane. The germinating cells when ripe become detached, and form free lymph cells.

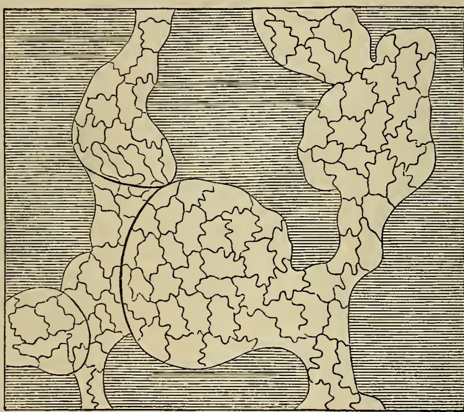


FIG. 57.—Lymphatic capillaries; showing the great variation in their size and shape.

It will be thus seen that there are two chief forms in which the lymphatics originate, namely, by spaces or sinuses lined by a complete epithelium and by irregular lacunæ, lined only on one side by a branched connective-tissue cell.

Lymphatic Glands (conglobate or absorbent glands) are small, oval or bean-shaped, flattened or rounded bodies, of a reddish-brown colour, placed at short intervals in the course of the small lymphatic

vessels. They are found in groups in the axilla, popliteal space, groin, lumbar region of the abdomen, round the root of the lungs, and in the neck, and are joined together by means of the lymphatic vessels which enter or leave them.

Each gland presents externally the appearance of being composed of lobules, and generally has at one side a slight depression or *hilus*, through which the blood-vessels enter the interior. The lymphatic vessels connected with the gland consist of a large one, apparently issuing from the very centre of the gland, called *vas*

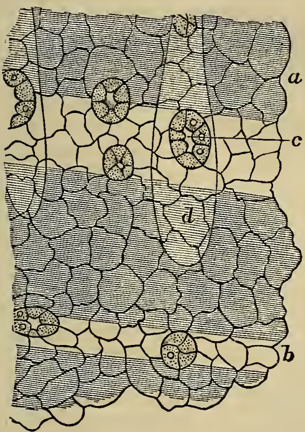


FIG. 58.—Peritoneum covering the central tendon of the diaphragm of a rabbit. *a.* Tendon bundle covered by squamous epithelial cells with wavy margins. *b.* Epithelium covering space between tendon bundles, cells of small size. *c.* One of the stomata, surrounded by germinating epithelium. *d.* Sinus of a lymphatic vessel.

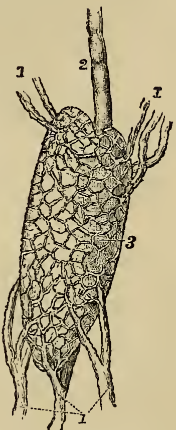


FIG. 59.—View of a lymphatic gland. 1, 1, 1. Vasa afferentia. 2. A vas efferens. 3. Body of the gland.

efferens, and numerous smaller ones passing into the interior at different parts of the periphery, each of these being called a *vas afferens.* On section the external part of the gland is found to be of a different colour and consistence to the interior, and hence the two parts are distinguished as *cortical* and *medullary.* The gland is surrounded by a capsule which is continuous with the outer coat of the afferent and efferent vessels; it is formed of white fibrous tissue, the fibres crossing each other in different directions, and enclosing connective-tissue corpuscles in their meshes. At the hilus the fibres of the capsule are continued into the interior of the gland, the fibrous tissue becomes mixed with a small quantity of unstriped muscle, and the bands so constituted radiate from the centre to

the periphery, and become connected with the interior of the capsule ; they thus form numerous septa which divide the cavity of the gland

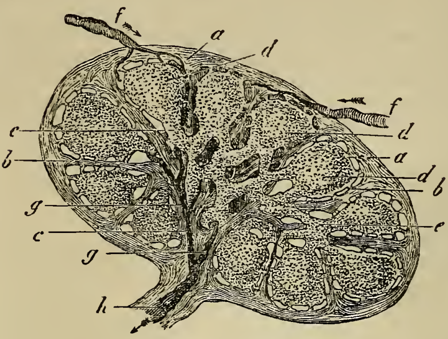


FIG. 60.—Section of a small lymphatic gland, half diagrammatically given, with the course of the lymph. *a.* The envelope. *b.* Septa between the alveoli of the cortical portion. *c.* Septa of the medullary portion, down to the hilus of the organ. *d.* Adenoid tissue. *e.* Lymph vessels of the medullary mass. *f.* Different lymphatic streams which surround the follicles, and flow through the interstices of the medullary portion. *g.* Confluence of these passing through the efferent vessel, *h*, at the hilus of the organ.

into spaces. In the cortical part of the gland the fibrous trabeculæ form thin lamellæ, and enclose relatively large oval spaces, called *alveoli* ($\frac{1}{60}$ to $\frac{1}{24}$ of an inch wide), which communicate with each other by small openings in the partitions. In the medullary part the trabeculæ exist as flattened cords or bands, which form by their communications a network, the meshes of which freely open into each other. The alveoli of the cortical and meshes of the medullary part are occupied by the proper glandular or adenoid tissue, which in the former takes the shape of oval masses (follicles), and in the latter that of cords or cylinders (medullary cylinders). In both cortex and medulla the gland pulp or substance is separated from the

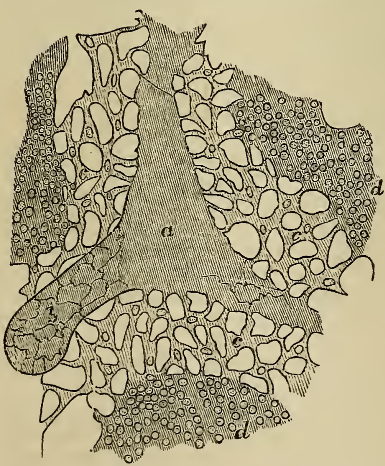


FIG. 61.—Part of medulla of a lymphatic gland. *a.* Trabecula cut longitudinally. *b.* Surface of the trabecula covered by epithelium. *c.* Lymph sinus. *d.* Medullary cylinders composed of adenoid tissue.

trabeculæ forming alveoli and meshes by a space of nearly uniform width throughout ; this is the *lymph sinus* or lymph channel. It

is not empty, but is occupied by retiform connective tissue, that is to say, ramified or anastomosing cells ; these support large numbers of lymph corpuscles, which are carried onwards by the current of lymph. The adenoid tissue which forms the great mass of the gland, consists of a reticulum of fine homogeneous fibrils or membranes, arranged so as to form a honeycomb, and covered by numerous flattened epithelial cells. The reticulum is crowded with lymph corpuscles of small size, and having an appearance resembling that of free nuclei. The adenoid tissue contains a dense network of capillary blood-vessels.

The afferent vessels, after branching upon and in the tissue of the capsule, open into the lymph sinus in the cortex of the gland ; the efferent vessels, on the other hand, commence by small branches connected with the sinus in the medullary meshes. The lymph sinus is, therefore, the channel through which the lymph passes in its course from the afferent to the efferent vessels, and it is plain that the lymph cells which it receives in such large numbers in passing through the gland are derived from the glandular or adenoid tissue filling up the great part of the cavities in the cortex and medulla. On entering a gland the lymphatic vessel loses all its coats except the inner epithelial one, which is continued over the trabeculæ, forming a delicate lining for these partitions.

The lymphatic glands above described are sometimes spoken of as *compound lymphatic glands*, to distinguish them from masses of lymphoid tissue found in various parts of the body, and described as *simple lymphatic glands.* Examples of the latter are the tonsils, glands at the root of the tongue, thymus gland, solitary and agminate glands of the intestine, and the Malpighian bodies of the spleen. These will be described in the section on the viscera, in connection with the organs of which the adenoid masses form a part.

SEROUS MEMBRANES.

These occur in the form of a thin transparent web which lines the interior of cavities containing viscera, and is so disposed as to facilitate movement. The chief examples are the pleuræ and pericardium in the chest, peritoneum in the abdomen, arachnoid in the cranium and spinal canal, and the tunica vaginalis in front of the testicle. A serous membrane consists of two parts, one which lines the cavity, called the parietal layer ; the other, which is reflected from the wall of the cavity, and is prolonged over the contained organ, the visceral layer. These two layers are in contact on their free surfaces ; and from this free surface a very small quantity of limpid fluid is secreted, which serves the purpose of a lubricating medium, and so facilitates the gliding of the enclosed organ in its cavity. The serous membranes are all closed sacs retaining their fluid contents, when from any cause there is an abnormal effusion. The only exception to this is the peritoneum in the female, where at the

extremity of the Fallopian tube the serous membrane is continuous with the mucous lining of the tube. In some cases, as the serous membrane of the heart and lungs, its arrangement is very simple; in others, as the peritoneum, it is very complex, owing to the number of organs contained in the cavity; but in all (except the arachnoid) the two layers can easily be made out. At the place where the reflection takes place, the vessels of the contained organ enter it. The viscus, although said to be surrounded by the serous membrane, is in reality outside of it. The accompanying plan of such a sac will give an idea of the manner of arrangement.

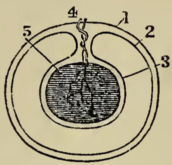


FIG. 62. — Plan of a serous membrane. 1. Wall of cavity. 2. Parietal layer of serous membrane. 3. Visceral layer. 4. Vessel entering at the reflection. 5. The contained organ.

Structure.—Serous membranes are lined by a layer of flattened epithelial cells with sinuous edges and clear oval nuclei, each containing one or more nucleoli. Openings exist in many of the serous membranes, which, as stated above, communicate with the lymphatic capillaries; they are called *stomata*, are commonly oval in shape, and are bordered by cells which are thicker and of a more granular character than those covering the rest of the surface. As these cells are actively growing, and often produce free corpuscles, they have been described by Klein under the name of *germinating epithelium*. Besides the stomata, other interruptions in the epithelial layer have been noted. These are called *pseudo-stomata;* they are not true openings, but are processes of protoplasm sent up to the surface by the connective-tissue cells of the subserous tissue. The deep layer of serous membranes consists of a connective-tissue ground substance formed of yellow and white fibres, and supporting the capillary vessels and lymphatics; the ground substance also contains branching connective-tissue cells lying in cell spaces, many of the processes of which pass up between the epithelial cells of the surface and form pseudo-stomata. The fluid secreted by serous membranes is almost identical with the fluid part of lymph, and from the fact that the cavities formed by serous

FIG. 63.—Tesselated epithelium from abdominal surface of central tendon of diaphragm of a rabbit, stained with nitrate of silver. *a*. Large epithelial cells covering the general surface of the membrane. *b*. Smaller cells over a lymphatic capillary, in which several pseudo-stomata may be seen.

membranes freely communicate with the lymphatic system through the medium of the stomata, it is now generally held that they are indeed lymph spaces or sacs. As withdrawn from healthy serous cavities the fluid coagulates spontaneously, but when it accumulates under conditions of disease (in dropsy, for instance), it requires for its coagulation the addition of some substance containing globulin.

SYNOVIAL MEMBRANES.

These membranes are nearly identical in structure with the serous membranes, but the secretion is more viscid and something like the white of egg, whence the name. They line the cavities of joints, and are interposed between tendons and bones when much friction or pressure is produced during their movements.

Three classes of synovial membranes have to be described—namely, those lining the cavities of joints, **Articular**; those forming closed sacs, **Bursal**; and those forming lubricating sheaths for tendons, **Vaginal** or **Ensheathing.**

1. **Articular Synovial Membranes** (*Synovial Capsules*).—These cover the interior of the ligaments enclosing a diarthrodial joint, and secrete a fluid called synovia, which lubricates the articular surfaces and ensures smooth movement. The membrane is not (as was formerly supposed) continued over the whole surface of the articular cartilage, but simply overlaps its margin to a very slight extent; at its termination it becomes firmly adherent to the cartilage. When a tendon passes through a joint, as for instance, the tendon of the biceps through the shoulder joint, it is invested by this membrane, which is often continued on it for some distance beyond the capsule of the joint. In large joints additional folds of synovial membrane, containing fat, pass between the bones, or are lodged in excavations near the articular surfaces; some of these receive the name of ligaments, others are simply described as synovial fringes.

2. **Bursal Synovial Membranes** (*Bursæ Mucosæ*).—In these the synovial membrane forms a shut sac, sufficient fluid being secreted to lubricate the opposed surfaces, aud the outer surface of the sac being connected with the neighbouring structures. Bursæ are found in all places where it is desirable to prevent friction between surfaces which move on each other, thus they are placed between the tendons of muscles, between tendons and the exterior of certain joints, and sometimes between a muscle and a bone. Many bursæ are subcutaneous, and are then of use to ward off external pressure; such are the bursæ found between the skin and the patella, and between the skin and the olecranon, or those on the styloid processes of the radius and ulna. Bursæ lying in contact with the capsule of a joint often become connected with the cavity of the joint.

3. **Vaginal or Ensheathing Synovial Membranes.**—These form sheaths for the tendons of many muscles, more especially those

on the palmar and dorsal surfaces of the wrist, and the tendons passing to the phalanges of the fingers and toes. They not only serve to lubricate those tendons, but are also the means by which they are connected with the bones, and with each other; small bands called "frena" passing from one part of the membrane to another.

Structure of Synovial Membrane.—Synovial membranes are formed entirely of connective tissue, the deep layer being composed of ramified corpuscles embedded in a ground substance. The free surface was formerly described as being covered by a single layer of flattened epithelial cells, but further investigation has established the fact that the only cells found on the surface are of the branched and anastomosing kind, similar to those in the deeper layer of the tissue, and that the surface between the cells is formed by albuminoid ground substance. Here and there, however, the cells become so aggregated together, as to present some resemblance to an epithelial layer; but this aggregation only takes place in isolated patches, and not over the whole membrane.

The synovial membrane passes a little beyond the edge of the articular cartilage, and its cells becoming changed in form and losing their processes come to bear a close resemblance to cartilage cells; it thus becomes quite impossible to determine the exact spot at which the membrane ceases. Synovial membranes are well supplied with blood-vessels which pass a little way into the cartilages, where they form a circle of anastomosis, and terminated by loops, the vessels which form them being dilated beyond the usual size of capillaries.

MUCOUS MEMBRANE.

Mucous membrane is the tissue which lines all the internal passages which communicate with the surface of the body. It secretes a viscid fluid called mucus, which protects and lubricates its surface, so as to allow of the passage of substances which otherwise would injure or irritate it. There are two great tracts of mucous membrane, called the gastro-pulmonary and genito-urinary. The first communicates with the surface of the body at the edge of the eyelid, nostril, mouth, and anus; the second at the orifice of the urethra in the male, of the vagina in the female. Every duct which opens into either of these tracts is a tubular prolongation of the mucous membrane; and the various glands which pour their secretions into the alimentary canal on the one hand, and those connected with the bladder and organs of generation on the other, are but complicated ramifications of that membrane continued to them through their respective ducts.

The **structure of mucous membrane** is analogous to that of serous membrane, but more complex. It consists of two portions—one, the **corium**, a tough fibro-vascular layer; the other the **epi-**

thelium, composed of one or more layers of cells which rest on the corium.

The corium in most situations is separated from the epithelial layer by a thin, structureless, transparent membrane—the **basement membrane**. Underneath this filmy structure lies the capillary plexus, and on it rest the epithelial cells.

The true **corium** consists of a congeries of vessels—capillaries and lymphatics—woven into a compact tissue by interlacing fibres of connective tissue. The pink colour of mucous membrane depends on the capillary plexus seen through the semi-transparent cellular epithelium. In certain situations plain or involuntary muscular fibres occur among the other fibres, especially in the alimentary canal. The arrangement of the vessels of the capillary plexus differs in each situation, so that a portion of mucous membrane under examination can be recognised by its vessels alone—as for instance the villi of the intestines, the air-cells of the lung, &c.

FIG. 64.—Goblet cell from trachea of cat.

The epithelium of mucous membrane may be in a single layer or stratified, and the individual cells may be scaly, columnar, or ciliated. A peculiar variety of epithelium has been described in actively secreting mucous membrane under the name of "goblet epithelium" or "goblet cells." There is little doubt that they are produced in the process of the secretion of mucus in the following manner. The cell-contents of the columnar cells become converted into mucin, which swells up, and distends the cell in its centre, so that it assumes the goblet-shape; the nucleus thus gets pressed to the distal end. The membrane covering the surface of the cell ultimately becomes detached, and the mucus is then poured out.

Submucous Tissue.—The corium is connected to the structures on which it lies by a layer of areolar tissue, which is dense and firm in some situations, where its fibres are continuous with the interlacing fibres of the corium; but in most it is loose, and permits the corium to glide on the surface on which it lies, so that it may be thrown into folds, or *rugæ*. The laxity of this submucous tissue renders it liable to be distended with fluid, as a result of inflammation, as in the case of chemosis of the conjunctiva and œdema of the glottis. The nature of the submucous tissue can be best examined by inflating a piece of the small intestine which has been inverted after the mesentery has been cut off close to its attachment to the bowel.

The arrangement of the mucous membrane, and the structure of the glands in connection with it, will be described along with the anatomy of the organs of which it constitutes a part.

SECRETING GLANDS.

The simplest example of secreting structure is to be found in the serous membranes, which have on their surface a layer of epithelial cells, performing the work of secretion; beneath this, a subepithelial

layer formed of connective-tissue corpuscles embedded in an albuminous ground substance, while in the ground substance and beneath it there is a fine plexus of capillary vessels, furnishing the blood from which the secretion is separated. However complicated glands may appear, it is easy to recognise in them the same three essential constituents as in serous membranes, namely, secreting cells, supporting tissue, and capillary vessels, but these three undergo various modifications in the different glands. In most of the glands the cells are of a spheroidal or irregular cubical form, and the supporting tissue is reduced to a homogeneous membrane, of great tenuity, called the "basement membrane."

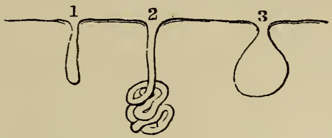


FIG. 65.—1. Simple follicle. 2. Tubular gland. 3. Saccular gland.

Glands may be divided into six forms, three of them being described as simple, and three as compound. The former are the simple follicle, saccule, and tubule; the latter the compound follicle, saccule, and tubule.

The **simple follicle** is merely a depression, resembling in shape the finger of a glove, and lined with cells mostly of the columnar variety, but with some granular spheroidal cells intermixed. The narrow cavity between the cells is called the **lumen** of the gland. The best examples of this form of gland are to be found in the small intestines, where they are called Lieberkuhn's follicles.

The **simple tubule** is an elongated follicle, the deeply seated end becoming convoluted like a ball of twine; the upper part of the tube is lined with squamous, and the lower with cubical epithelium. The sweat glands of the skin are examples of the simple tubular gland.

The **simple saccule** is a pouch-like sac, dilated below, and connected with the surface above by a narrow neck. The saccule is crowded with cells, chiefly of spheroidal form, so that little or no free cavity or lumen is left. The sebaceous glands connected with the hair follicles of the skin are examples of this form of gland.

The **compound follicular gland** is a follicle, the termination of which is cleft into two or three divisions. The gastric follicles near the pyloric end of the stomach have this form.

The **compound tubular gland** consists of branching tubules which become convoluted at their deep extremity. This arrangement may be observed in the tubuli uriniferi of the kidney.

The **compound saccule** is better known under the title of **racemose gland.** The salivary glands, pancreas, mammary gland, the lachrymal gland, and Brunner's glands of the duodenum belong to this class. The racemose gland presents to the naked eye the appearance of a number of little lobules, held together by connective tissue, and by the small blood-vessels which enter or leave them. Each lobule is composed of a number of saccules, called **acini,** lined by

large protoplasmic cells, with nuclei near their attached margins. The cells are so large as almost to fill the entire saccule, only a small central cavity or lumen being left between them. The cells are supported by a framework of connective tissue, which serves also to

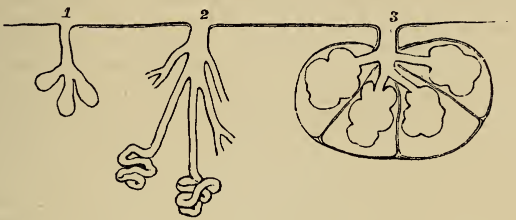


FIG. 66.—1. Compound follicle. 2. Compound tubular gland. 3. Compound saccular or racemose gland.

connect the saccules, and to support a network of capillary vessels which supplies blood to the gland cells. The acini of a lobule open into a common duct, and the ducts from the lobules unite to form larger ducts, which generally terminate in a single excretory channel

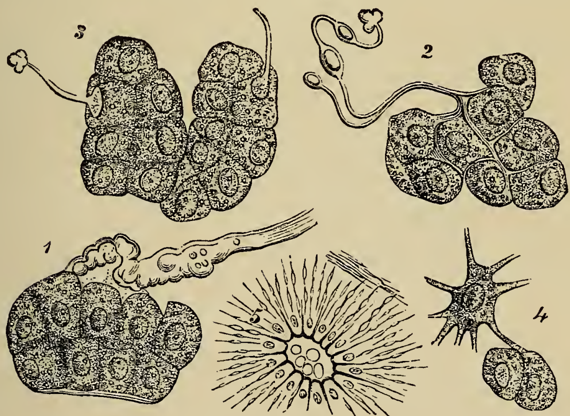


FIG. 67.—Modes of termination of nerves in salivary glands. 1 and 2. Branching of the nerves between the salivary cells. 3. Termination of the nerve in the nucleus. 4. Union of a ganglion cell with a salivary cell. 5. Varicose nerve fibres entering the cylindrical cells of the excretory ducts.

for the whole organ; sometimes, however, as in the lachrymal and sublingual glands, the terminal ducts are eight or ten in number. The ducts are lined with cylindrical epithelium.

The blood-vessels distributed to glands are numerous and of large

size. They are remarkable for their rapid increase and diminution in size, according to the activity of the gland, or the reverse. The nerves distributed to glands are partly derived from the cerebro-spinal and partly from the sympathetic system; many of the latter are distributed to the blood-vessels, and serve to regulate the supply of blood to the gland. The nerves distributed to the salivary glands form a plexus between the lobules, in the midst of which small ganglia are found. The plexus is composed chiefly of medullated fibres, and the branches given off from it are also medullated, till they penetrate the basement membrane of the acini, or the wall of the ducts; they then lose their medullary sheath, the axis cylinder splits up into numerous primitive fibrils, which pass into the substance of the epithelial cells of the ducts and the gland cells of the alveoli (Pflüger), often reaching the nuclei of those cells. Ganglion cells are also described as directly connected by their processes with the gland cells of salivary glands.

PART II.

OSTEOLOGY.

The skeleton is the bony framework which forms the support of the body, and affords points of attachment for the muscles by which the movements are effected. The fundamental part of the skeleton is the spine or vertebral column (from *verto*, I turn), because it is the axis around which all the other parts are disposed and on which they move. It exists in all animals possessing an internal skeleton, which are therefore called vertebrate animals.

The vertebrate skeleton consists of a series of segments articulated with each other, each of which resembles its immediate neighbour in general plan, although there are great differences between those taken from different regions of the same skeleton. As a general rule each segment consists of three essential parts. A centre, *centrum*, one of the subdivisions of the vertebral column or the *body* of a vertebra. Behind and in front, from this centre two plates of bone project, so arranged as to enclose a canal. That behind, being for the lodgment of the nerve centres, is called the *neural canal.* That in front, for the lodgment of the organs for the circulation and preparation of the blood, is called the visceral or *hœmal canal* or cavity.

Fig. 68.—Caudal vertebra of a fish. 1. Centrum. 2. Neural spine. 3. Hæmal spine. 4. Neural canal. 5. Hæmal canal. 6. Neural arch. 7. Hæmal arch.

The plates of bone which enclose the neural canal are called the *neurapophyses*, and together they constitute the neural *arch.* In like manner there is a hæmal *arch* formed by *hœmapophyses.* These *elements* of a vertebral segment are seen in their greatest simplicity and perfection in the caudal vertebra of a fish. In other parts of the same skeleton, and in the skeletons of other animals, great differences are found, some of the parts of either arch being absent, and many additional *elements* introduced; the only constant part being the centrum or body which exists as the only *element* in the last bone of the coccyx and the extremity of the tails of animals. In the human skeleton the most perfect segment is that of which the first

dorsal vertebra is a part. The body of the vertebra is the centrum; the vertebral ring is the neural arch; and the hæmal arch is constituted by the first rib and its cartilage along with the upper piece of the sternum. Such a segment is called a complete vertebra, because it has a hæmal as well as a neural arch. The first seven dorsal are the only complete vertebræ in the human skeleton if we exclude the skull, the segments of which are often considered as modified vertebræ; the parts of the base being the centra, the flat bones of the cranium the neural arches, and the jaws the hæmal arches. The other vertebral segments are incomplete from the absence of the hæmal arches; in the cervical region their place being occupied by the structures forming the neck; and in the abdomen by the muscular walls of that cavity. In both, however, there are traces of the segmental plan, the anterior portions of the transverse processes of the cervical and lumbar vertebræ being *rudimentary* ribs, and the *lineæ transversæ* in the *rectus* muscle being the homologues of costal cartilages.

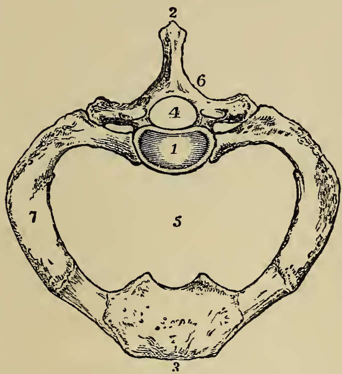


FIG. 69.—Segment of the skeleton at the level of the first dorsal vertebra. 1. Body or centrum. 2. Neural spine. 3. Hæmal spine. 4. Neural canal. 5. Hæmal canal. 6. Neural arch. 7. Hæmal arch.

The trunk of the body thus formed of vertebral segments has connected with it the limbs, which are reckoned as appendages for the purposes of movement, and which vary in different animals according as their locomotion is on the land, in the water, or in the air. Varied as are the modifications, there is a sufficient similarity between the limbs of terrestrial animals, the wings of birds, and the fins of fishes to enable us to see that they are all constructed on the same principle.

GENERAL CHARACTERS OF BONES.

Bones are divisible into four classes:—**Long, flat, round,** and **irregular.**

The **long** bones are found principally in the limbs, and consist of a shaft and two extremities. The shaft is cylindrical or prismoid in form, dense and hard in texture, and hollowed in the interior into a medullary canal. The extremities are broad and expanded to articulate with adjoining bones; and are cancellous in internal structure. Upon the exterior of the bones are processes and rough surfaces for the attachment of muscles, and foramina for the transmission of vessels and nerves. The character of long bones is, there-

fore, their general type of structure and their divisibility into a central portion and extremities, and not so much their length; for there are certain long bones, as the second phalanges of the toes, which are less than a quarter of an inch in length, and which, in some instances, exceed in breadth their longitudinal axis. The long bones are, the clavicle, humerus, radius and ulna, femur, tibia and fibula, metacarpal bones, metatarsal, phalanges, and ribs.

Flat bones are composed of two layers of dense bone with intermediate loose structure. They are adapted to enclose cavities; have processes upon their surface for the attachment of muscles; and are perforated by foramina for the passage of nutrient vessels to the cavities in their interior, and for the transmission of vessels and nerves. They articulate with long bones by means of smooth surfaces plated with cartilage, and with each other, either by fibro-cartilaginous tissue, as at the symphysis pubis; or by suture, as in the bones of the skull. The two condensed layers of the bones of the skull are named, tables; and the intermediate open structure, diploë. The flat bones are, the occipital, parietal, frontal, nasal, lachrymal, vomer, sternum, scapulæ, and innominate bones.

Short or **round** bones have an exterior shell of dense bone filled with spongy or cancellous substance; of this sort are the bones of the carpus and tarsus, and the sesamoid bones, including the patella.

The **irregular** bones include all that remain after the long, short, and flat bones have been excluded. They are essentially irregular in their form, in some parts flat, in others short and thick; and are constructed on the same general principle as other bones. The bones of this class are, the temporal, sphenoid, ethmoid, superior maxillary, inferior maxillary, palate, inferior turbinated, hyoid, vertebræ, sacrum, and coccyx.

NUMBER OF BONES.

The entire osseous framework of the body constitutes the skeleton, which in the adult man is composed of two hundred distinct bones. They may be thus arranged:—

Cranium	8	Skull.
Face	14	
Vertebral column	24	
Sacrum and coccyx	2	
Sternum and ribs	25	
Upper extremities	64	
Lower extremities	60	
Patellæ	2	
Os hyoides	1	
	200	

In addition to this number, there are six ossicles of the ear and a variable number of sesamoid bones.

The *skeleton* is divisible into: 1. The vertebral column, or central axis. 2. The head and face, or superior development of the central axis. 3. The hyoid arch. 4. The shoulder girdle and upper extremities. 5. The pelvic girdle and lower extremities.

VERTEBRAL COLUMN.

The **vertebral column** is the central axis which supports the head, thorax, and upper extremities. It consists of numerous separate bones called *vertebræ*, which, although possessing a limited degree of motion on each other, yet give to the whole column considerable flexibility.

The vertebræ admit of a division into *true* and *false*. The true vertebræ are twenty-four in number, and are classed, according to the three regions of the trunk which they occupy, into cervical, dorsal, and lumbar. The false vertebræ consist of nine pieces united into two bones, the sacrum and coccyx. The arrangement of the vertebræ may be better comprehended by means of the accompanying table:—

True vertebræ 24	7 Cervical, 12 Dorsal, 5 Lumbar.	False vertebræ 9	5 Sacrum, 4 Coccyx.

Characters of a Vertebra.—A vertebra consists of a body or centrum, two laminæ, a spinous process, two transverse processes, and four articular processes. The *body* is the solid part of the vertebra; and, by its articulation with adjoining vertebræ, gives strength and support to the trunk. It is flattened above and below, convex in front, and slightly concave behind. Its anterior surface is constricted around the middle, and pierced by numerous small openings, which give passage to nutrient vessels. On its posterior surface is a single irregular opening, or several, for the exit of the venæ basis vertebræ.

The *laminæ* commence upon the sides of the posterior part of the body of the vertebræ by two *pedicles;* they then expand, and, arching backwards, enclose a *foramen*, which serves for the protection of the spinal cord. The upper and lower borders of the laminæ are rough for the attachment of the ligamenta subflava. The concavities above and below the pedicles are the *intervertebral notches.* The *spinous process* stands backwards from the angle of union of the laminæ. It is the succession of these projecting processes along the middle line of the back, that has given rise to the common designation of the vertebral column, the *spine.* The use of the spinous process is for the attachment of muscles. The *transverse processes* project one at each side from the laminæ of the vertebra; they also are intended

for the attachment of muscles. The *articular processes*, four in number, stand upwards and downwards from the laminæ, to articulate with the vertebra above and below.

Cervical Vertebræ.—In a cervical vertebra the body is smaller than in the other regions; it is broad from side to side, concave on the upper surface and convex below, so that, when articulated, the vertebræ lock the one into the other. The lateral borders of the upper surface are produced into prominent ridges, and the anterior edge of the lower surface overlaps that of the vertebræ below. The *laminæ* are narrow and long, and the included *spinal foramen* large and triangular. The *superior intervertebral notches* are slightly deeper than the inferior; the *inferior* being the broadest. The *spinous process* is short and bifid at the extremity, increasing in length from the fourth to the seventh. The *transverse processes* are also short and bifid, and deeply grooved along the upper surface for the cervical nerves. Piercing the base of the transverse

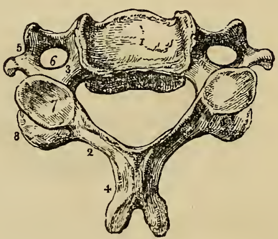


FIG. 70.—A central cervical vertebra, seen upon its upper surface. 1. The body, concave in the middle, and rising on each side into a sharp ridge. 2. The lamina. 3. The pedicle, rendered concave by the superior intervertebral notch 4. The bifid spinous process. 5. The bifid transverse process. The number is placed in the concavity between the anterior and posterior tubercle. 6. The vertebral foramen. 7. The superior articular process, looking backwards and upwards. 8. The inferior articular process.

process is the vertebral foramen,* which gives passage to the vertebral artery and vein, and vertebral plexus of nerves. The artery commonly passes only through the vertebral foramina of the six upper vertebræ, the vein more frequently passes through the foramina of all seven. The transverse processes in this region are formed by two small developments, which proceed, the one from the side of the body, the other from the pedicle, and unite near their extremities to enclose the circular area of the vertebral foramen. The anterior of these processes is the rudiment of a cervical rib; the posterior, the homologue of the transverse processes in the dorsal region. The extremities of these developments are the *anterior* and *posterior tubercle* of the transverse process. The *articular processes* are oblique; the superior looking upwards, backwards, and a little inwards; the inferior downwards, forwards, and a little outwards.

There are three peculiar vertebræ in the cervical region:—The first, or atlas; the second, or axis; and the seventh, or vertebra prominens.

* Sometimes a small additional opening exists by the side of the vertebral foramen, in which case it is traversed by a second vein.

The **Atlas** (named from supporting the head) is a simple ring of bone, without body, and composed of arches and processes. The *anterior arch* is the shortest; it has a tubercle on its anterior surface, for the attachment of the longus colli muscle; and on its posterior aspect is a smooth surface, for articulation with the odontoid process of the axis.

The *posterior arch* is longer and more slender than the anterior, and flattened from above downwards; at its middle is a rudimentary spinous process; and upon its upper surface, near the articular processes, a shallow groove at each side (sometimes converted into a foramen), which represents a superior intervertebral notch, and supports the vertebral artery (just before it perforates the dura mater) and the first cervical nerve. The intervertebral notches are peculiar, from being situated behind the articular processes, instead of before them as in the other vertebræ. The *transverse processes* are not bifid; they are remarkably large and long, and are pierced

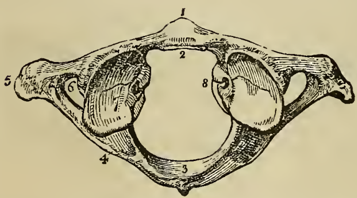


Fig. 71.—The upper surface of the atlas. 1. The anterior tubercle projecting from the anterior arch. 2. The articular surface of the odontoid process on the posterior surface of the anterior arch. 3. The posterior arch, with its rudimentary spinous process. 4. The intervertebral notch. 5. The transverse process. 6. The vertebral foramen. 7. Superior articular surface. 8. Tubercle for the attachment of the transverse ligament. The tubercle referred to is just above the head of the figure; the convexity below it is the margin of the inferior articulating process.

by the foramina for the vertebral arteries. The *articular processes* are situated on the most bulky and strongest part of the atlas. The superior are oval and concave, and look inwards, so as to form a kind of cup for the condyles of the occipital bone, and are adapted to the nodding movements of the head; the inferior are circular, and nearly horizontal, to permit of the rotatory movements. Upon the inner face of the *lateral mass* which supports the articular processes, is a small tubercle at each side, to which the extremities of the transverse ligament are attached, a ligament which divides the ring of the atlas into two unequal segments: the smaller and anterior, for receiving the odontoid process of the axis; the larger and posterior, to give passage to the spinal cord and its membranes.

The **Axis** (vertebra dentata) is so named from having a process, shaped like a tooth, upon which the head turns on a pivot. The *body* is of large size, and supports a strong process, the odontoid, which rises perpendicularly from its upper surface. The *odontoid process* presents two articulating surfaces; one on its anterior face, to articulate with the anterior arch of the atlas; the other on its posterior face, for the transverse ligament: the latter surface constricts the base of the process, which has given rise to the term *neck* applied

to this part. The tip of the odontoid process is often marked by a spine or ridge which gives attachment to the middle check ligament (ligamentum suspensorium dentis). Upon each side of its apex is a rough depression, for the attachment of the alar ligaments; and running down from its base, on the anterior surface of the body of the vertebra, a vertical ridge, with a depression at each side for the attachment of the longus colli muscle. The *laminæ* are large and strong, and unite posteriorly to form a long and bifid *spinous process*, which is concave beneath. The *transverse processes* are rudimentary, not bifid, and project only so far as to enclose the vertebral foramen, which is directed obliquely outwards instead of perpendicularly as in the other vertebræ. The *superior articulating processes* are situated on the body of the vertebra, at each side of the odontoid process. They are circular and nearly horizontal, having a slight inclination outwards. The *inferior articulating processes* look downwards and forwards, as do the same processes in the other cervical vertebræ.

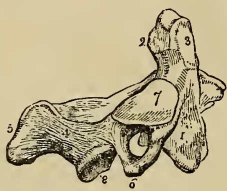


FIG. 72.—A lateral view of the axis. 1. The body; the number is placed on the depression which gives attachment to the longus colli. 2. The odontoid process. 3. The smooth facet on the anterior surface of the odontoid process which articulates with the anterior arch of the atlas; the facet for the transverse ligament is beneath No. 2, where the constriction called the neck of the odontoid process is seen; the bulk of the process between 2, 3, would represent its head. 4. The lamina. 5. The spinous process. 6. The transverse process, pierced obliquely by the vertebral foramen. 7. The superior articular surface. 8. The inferior articular process.

The *superior intervertebral notch* is remarkably shallow, and lies behind the articular process as in the atlas; the *inferior notch* lies in front of the articular process, as in the rest of the vertebræ. The lower surface of the body is convex, and is received into the concavity upon the upper surface of the third vertebra.

The **Vertebra prominens**, or seventh cervical, approaches in character the upper dorsal vertebræ. It has received its designation from having a very long spinous process, which is single and terminated by a tubercle, and forms a projection on the back part of the neck; to the extremity of this process the ligamentum nuchæ is attached. The transverse processes are but slightly grooved along the upper surface, have each a small foramen for the transmission of the vertebral vein, and present only a rudimentary bifurcation at their extremity. Sometimes the anterior tubercle represents a small but distinct rib.

Dorsal Vertebræ.—The *body* of a dorsal vertebra is as long from before backwards as from side to side, particularly in the middle of the dorsal region; it is thicker behind than before, and marked on each side by two half-articulating surfaces for the heads of two ribs. Its upper and lower surfaces are somewhat heart-shaped, and are nearly flat, but have a slightly sunken centre, with distinct margins

of dense, smooth bone; in the recent state this is occupied by a plate of cartilage. The *pedicles* are strong, and the *laminæ* broad and thick; the spinal *foramen* small and round, and the inferior *intervertebral notch* of large size; the superior can scarcely be said to exist. The *spinous process* is long, prismoid, directed very obliquely downwards, and terminated by a tubercle. The *transverse processes* are large and strong, and directed obliquely backwards. Upon the anterior and superior aspect of their summits is a small facet for the articulation

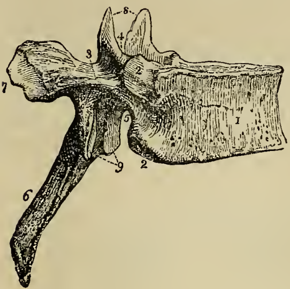


FIG. 73.—Lateral view of a dorsal vertebra. 1. The body. 2, 2. Articular facets for the heads of ribs. 3. The pedicle. 4. The superior intervertebral notch. 5. The inferior intervertebral notch. 6. The spinous process. 7. The extremity of the transverse process, marked by an articular surface for the tubercle of a rib. 8. The two superior articular processes looking backwards. 9. The two inferior articular processes looking forwards.

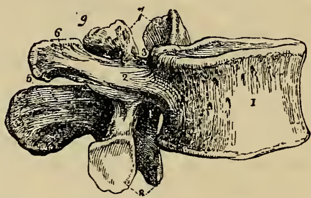
of the tubercle of a rib. The *articular processes* are vertical, the superior facing backwards, slightly upwards and outwards; the inferior forwards, slightly downwards and inwards.

The **peculiar vertebræ** in the dorsal region are, the first, ninth, tenth, eleventh, and twelfth. The **first** dorsal vertebra approaches very closely in character the last cervical. The body is broad from side to side, and concave above. The superior articular processes are oblique, and the spinous process horizontal. It has an entire articular surface for the first rib, and a half surface for the second. The **ninth** dorsal vertebra has only one half-articular surface at each side. The **tenth** has a single entire articular surface at each side. The **eleventh** and **twelfth** have each a single entire articular surface at each side; they approach in character the lumbar vertebræ; their transverse processes are very short, and have no articulation with the corresponding ribs. The articular facets are placed partly on the thick and strong laminæ, and partly on the bodies. The transverse processes of the twelfth dorsal vertebra are rudimentary, and its inferior articular processes are convex and look outwards.

Lumbar Vertebræ.—These are the largest pieces of the vertebral column. The *body* is broad and large, its upper and lower surfaces are nearly flat, and present a kidney-shaped outline. The *pedicles* very strong; the *laminæ* short, thick, and broad; the *inferior intervertebral notches* very large, and the spinal *foramen* large and oval. The *spinous process* is thick and broad. The *transverse processes* are slender, pointed, and directed very slightly backwards. The superior *articular processes* are concave, and look backwards and in-

wards ; the inferior convex, looks forwards and outwards. Projecting backwards and upwards from the superior articular process is a convex oval tubercle called the mammillary process (metapophysis), and in a well-marked vertebra there is at the base of this a smaller

FIG. 74.—Lateral view of a lumbar vertebra. 1. The body. 2. The pedicle. 3. The superior intervertebral notch. 4. The inferior intervertebral notch. 5. The spinous process. 6. The transverse process. 7. The superior articular processes. 8. The inferior articular processes. 9. The mammillary process.



tubercle called the accessory process (anapophysis). The last lumbar vertebra differs from the rest in having the body very much bevelled posteriorly, so as to be thick in front and thin behind, and the transverse processes thick and large.

General Considerations.—Viewed as a whole, the vertebral column represents two pyramids applied base to base, the superior being formed by all the vertebræ from the second cervical to the last lumbar, the inferior by the sacrum and coccyx. Examined more attentively, it will be seen to be composed of four irregular pyramids, applied to each other by their smaller extremities and by their bases. The smaller extremity of the uppermost pyramid is formed by the axis, or second cervical vertebra ; and its base, by the first dorsal. The second pyramid is inverted ; having its base at the first dorsal, and the smaller end at the fourth. The third pyramid commences at the fourth dorsal, and gradually enlarges to the fifth lumbar. The fourth pyramid is formed by the sacrum and coccyx.

The **bodies** of the vertebræ are broad in the cervical region ; narrowed almost to an angle in the middle of the dorsal, and again broad in the lumbar region.

The **arches** are broad and imbricated in the cervical and dorsal regions, the inferior border of each overlapping the superior of the next ; in the lumbar region an interval is left between them. A considerable interval exists between the cranium and atlas, and another between the last lumbar vertebra and sacrum.

The **spinous processes** are horizontal in the cervical, and become gradually oblique in the upper part of the dorsal region. In the middle of the dorsal region they are nearly vertical, and imbricated, and towards its lower part assume the direction of the lumbar spines, which are quite horizontal.

The **transverse processes**, developed in their most rudimentary form in the axis, gradually increase in length to the first dorsal vertebra. In the dorsal region they project obliquely backwards, and diminish suddenly in length in the eleventh and twelfth vertebræ, where they are very small. In the lumbar region they suddenly

increase in size, the last lumbar being especially large and strong. The transverse processes consist essentially of two parts, the anterior of which in the dorsal region is the rib, while the posterior retains the name of transverse process. In the cervical region these two elements are quite apparent, both by their different points of attachment to the vertebra, and by the vertebral foramen which divides them at their base.

The **intervertebral foramina** formed by the juxtaposition of the intervertebral notches are smallest in the cervical region, and gradually increase to the last lumbar. On each side of the spinous processes, and extending the whole length of the column, is the *vertebral groove*, which is shallow and broad in the cervical, and deeper and narrower in the dorsal and lumbar regions. It lodges the principal muscles of the back.

Curves of the Vertebral Column.—Viewed from the side, the vertebral column presents several curves, the principal of which is situated in the dorsal region, the concavity looking forwards. In the cervical and lumbar regions the column is convex in front; and in the pelvis an anterior concave curve is formed by the sacrum and coccyx. The dorsal curve is due to the bodies of the vertebræ in that region being thicker behind than in front; the cervical curve depends on the greater thickness of the intervertebral substance in front, and the lumbar curve results in the lower part from the thickness of the body of the last vertebra anteriorly, and in the upper part from the intervertebral substance being thicker in front. Besides the antero-posterior curves, a slight lateral curve sometimes exists in the dorsal region, having its convexity towards the right side.*

Development.—The vertebræ are developed by three primary and five secondary centres or epiphyses. The **primary centres** are, one for each lamina, and one for the body; the **epiphyses**, one for the apex of the spinous process, one for that of each transverse process, one for the upper and one for the under surface of the body. Exceptions to this mode of development are met with in the atlas, axis, vertebra prominens, and lumbar vertebræ. The *atlas* has three centres; one for each lateral mass, and one (sometimes two) for the anterior arch. The *axis* has six; one (sometimes two) for the body, two placed side by side in the base of the odontoid process, and a third at its tip; lastly, one for each lamina. The *vertebra prominens* has two additional centres for the anterior or costal segments of the transverse processes, and the *lumbar vertebræ*, two for the mammillary processes.

The primary centres of the vertebræ make their appearance during

* The question of the existence of a normal lateral curve has been much discussed. Dr. David Foulis, as the result of a series of observations made in the post-mortem room of the Glasgow Royal Infirmary, finds that out of 110 cases there was lateral deviation in 58, the convexity of the curve being towards the right in 39 instances, and towards the left in 19; the curves were not restricted to any one part of the dorsal or lumbar regions, but occurred in almost every part. From this he infers that there is no customary lateral deviation, but that such curves frequently arise, probably in consequence of habitual faulty posture in working at trades, &c.

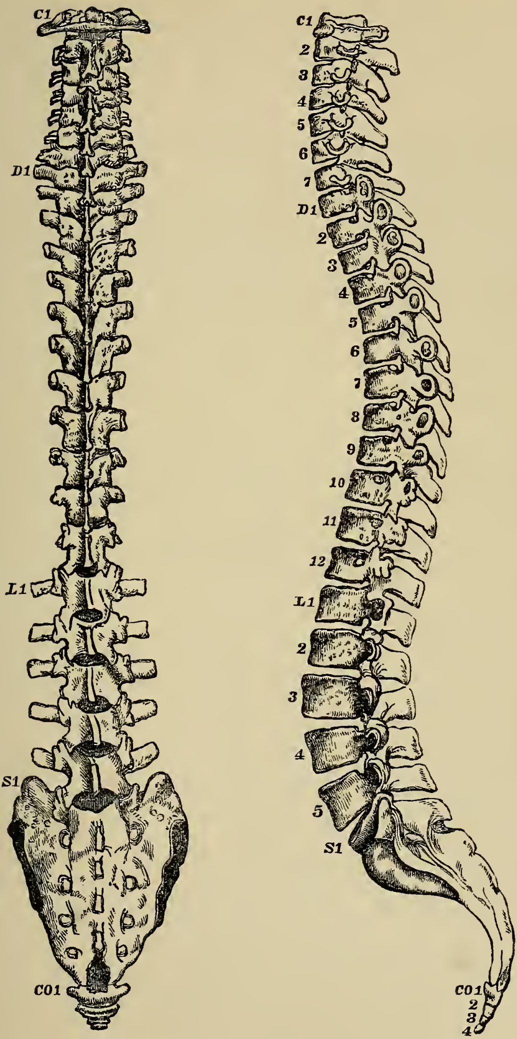


FIG. 75.—Posterior and lateral view of spinal column.

the seventh or eighth week of embryonic existence, the laminæ being somewhat in advance of the body. From the laminæ are produced the spinous, transverse, and articular processes, and the sides of the body; they unite, to complete the arch, one year after birth, and with the body during the fifth year. The epiphyses for the extremities of the spinous and transverse processes make their appearance at fifteen or sixteen, and become united to the rest of the bone between twenty and twenty-five. The epiphyses of the body are somewhat later in appearance, and are consolidated between the periods of twenty-five and thirty years of age.

The ossific centres, for the lateral masses, of the *atlas*, appear at the same time as those of the other vertebræ; they unite posteriorly at the end of the second year. The one or two centres of the anterior arch appear during the first year, and become consolidated with the lateral pieces during the fifth or sixth year. The *axis* develops its lateral pieces at the same time as the other vertebræ; they join posteriorly soon after birth, and with the body during the fourth or fifth year. The centres for the body and odontoid process appear during the sixth month, and are consolidated during the third year. The body of the axis is more largely developed at birth than that of the other vertebræ. The costal segments of the *vertebra prominens* appear during the sixth month, and become united to the body at the fifth or sixth year; they sometimes remain permanently separate, and constitute cervical ribs. The lumbar vertebræ have separate centres for the mammillary processes, but the transverse process of the first lumbar is sometimes developed altogether from a separate centre, and may remain permanently separate, in that case forming a lumbar rib.

The ossification of the arches of the vertebræ commences from above, and proceeds gradually downwards; hence arrest of development gives rise to spina bifida, generally in the loins. Ossification of the bodies, on the contrary, commences near the centre, and proceeds towards the extremities of the column; hence imperfection of the bodies occurs either in the upper or lower vertebræ.

Attachment of Muscles.—To the *atlas* are attached nine pairs of muscles; the longus colli, rectus anticus minor, rectus lateralis, rectus posticus minor, obliquus superior and inferior, splenius colli, levator anguli scapulæ, and first intertransversales.

To the *axis* are attached eleven pairs—viz., longus colli, intertransversales, obliquus inferior, rectus posticus major, interspinales, semi-spinalis colli, multifidus spinæ, levator anguli scapulæ, splenius colli, transversalis cervicis, and scalenus medius.

To the remaining *vertebræ* collectively, thirty-one pairs and one single muscle—viz., *posteriorly*, trapezius, latissimus dorsi, levator anguli scapulæ, rhomboideus minor and major, serratus posticus superior and inferior, splenius, sacro-lumbalis, longissimus dorsi, spinalis dorsi, cervicalis ascendens, transversalis cervicis, trachelo-mastoid, complexus, semispinalis dorsi and colli, multifidus spinæ, interspinales, intertransversales, levatores costarum: *anteriorly*, rectus

anticus major, longus colli, scalenus anticus, medius, and posticus, psoas magnus, psoas parvus, quadratus lumborum, diaphragm, obliquus internus and transversalis.

The **SACRUM** is a triangular bone, situated at the lower extremity of the vertebral column, and formed by the consolidation of five

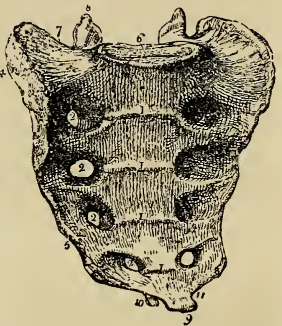


FIG. 76.—The sacrum seen upon its anterior surface. 1, 1. Transverse lines marking the original constitution of the bone of five pieces. 2, 2. Anterior sacral foramina. 3. Promontory of the sacrum. 4. Ear-shaped surface to articulate with the ilium. 5. The sharp edge to which the sacro-ischiatic ligaments are attached. 6. The vertebral articular surface. 7. The broad triangular surface which supports the psoas muscle and lumbosacral nerve. 8. Articular process of the right side. 9. Inferior extremity, or apex of the sacrum. 10. One of the sacral cornua. 11. The notch which is converted into a foramen by the coccyx.

false vertebræ. It is divisible into an anterior and posterior surface, two lateral and a superior border, and an inferior extremity.

The *anterior surface* is concave, and marked by four transverse lines, which indicate its original constitution of five separate pieces. At the extremities of these lines, on each side, are the four anterior sacral foramina, which diminish in size from above downwards, and transmit the anterior sacral nerves. The projection of the superior piece is the sacro-vertebral angle or *promontory*.

The *posterior surface* is narrower than the anterior, and convex. On the middle line is a rough crest, formed by the rudiments of four spinous processes, the fifth remaining undeveloped, and exposing the lower termination of the sacral canal. Immediately external to and parallel with the median crest, is a range of five small tubercles which represent the articular processes of the true vertebræ; beyond these is a shallow groove in which the four posterior sacral foramina open, and farther outwards, a range of five tubercles corresponding with the transverse processes of the lumbar vertebræ. The lowest pair of articular tubercles bound on each side the termination of the sacral canal, and send each a process downwards to articulate with the coccyx. The two descending processes are the *sacral cornua*. The posterior sacral foramina are smaller than the anterior, and transmit the posterior sacral nerves. Of the posterior transverse tubercles the *first* corresponds with the angle of the superior border of the bone; the *second* is small, and enters into the formation of the sacro-iliac articulation; the *third* is large, and gives attachment to the oblique sacro-iliac ligament; the *fourth* and *fifth* are smaller, and serve for the attachment of the sacro-ischiatic ligaments.

The *lateral border* of the sacrum presents superiorly a broad and

ear-shaped (auricular) surface to articulate with the ilium; and inferiorly a sharp edge, to which the greater and lesser sacro-ischiatic ligaments are attached. The back part of this border is marked by rough prominences and deep depressions for the posterior sacro-iliac ligaments.

On the *superior border*, in the middle line, is an oval articular surface, corresponding with the under part of the body of the last lumbar vertebra; and on each side a broad triangular surface, which supports the lumbo-sacral nerve and psoas magnus muscle. Immediately behind the vertebral articular surface is the triangular entrance of the sacral canal; and, on each side of this opening, an articular process, which looks backwards and inwards, like the superior articular processes of the lumbar vertebræ. In front of each articular process is an intervertebral notch.

The *inferior extremity* of the bone presents a small oval surface

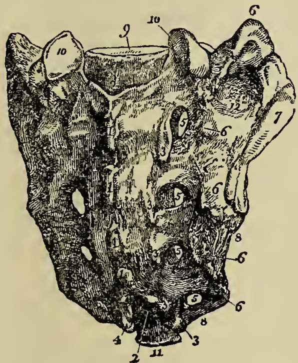


FIG. 77.—Posterior view of the sacrum. 1, 1. The four rudimentary spinous processes. 2. The sacral canal. 3, 3. Rudimentary articular processes. The lowest of these processes, with the corresponding process of the opposite side, 4, are the sacral cornua. 5, 5. The four posterior sacral foramina. 6, 6. Posterior transverse tubercles. 7. The auricular surface. 8. Sharp edge for the attachment of the sacro-ischiatic ligaments. 9. Surface for articulation with the body of the last lumbar vertebra. 10, 10. Articulating facets of the articular processes. 11. Apex of the sacrum by which it articulates with the coccyx. 12. Rough surface for the attachment of the posterior sacro-iliac ligaments.

which articulates with the coccyx; and on each side a notch, which, with a corresponding notch in the upper border of the coccyx, forms the foramen for the transmission of the fifth sacral nerve.

The sacrum presents some variety in respect of curvature, and of the number of pieces which enter into its structure. The curve is often very slight, and situated only near the lower part of the bone; while in other subjects it is considerable, and occurs at the middle of the sacrum. It is sometimes composed of six pieces, more rarely of four, and, occasionally, the first and second pieces remain permanently separate. The female sacrum is wider and shorter than the male, its curvature is less, and is almost confined to the lower part of the bone; it also forms a greater angle with the rest of the vertebral column.

Development.—By *thirty-five* points of ossification; five for each of the first three pieces—viz., one for the body, one for each lateral

portion, and one for each lamina; and three for each of the last two—namely, one for the body and one for each lateral portion. In the progress of growth, and after puberty, fourteen epiphysal centres are added—namely, two for the surfaces of each body, one for each auricular surface, and one for the thin edge of each lateral border. Ossification begins in the bodies of the sacral pieces somewhat later than in those of the true vertebræ: the first three appearing during the eighth and ninth week, and the last two at about the middle of intra-uterine existence. Ossification of the laminæ takes place during the interval between the sixth and ninth month. The epiphyses for the upper and under surface of the bodies are developed during the interval between the fifteenth and eighteenth year; and for the auricular and marginal piece, after twenty. The two lower vertebral pieces, although the last to appear, are the first to be completed (between the fourth and fifth year), and unite by their bodies. The union of the bodies takes place from below upwards, and finishes between the twenty-fifth and thirtieth year with the first two pieces.

Articulation.—With *four* bones; the last lumbar vertebra, ossa innominata, and coccyx.

Attachment of Muscles.—To *seven* pairs; *in front*, pyriformis; *on the side*, coccygeus; and *behind*, gluteus maximus, latissimus dorsi, erector spinæ, and multifidus spinæ.

The **COCCYX** (κόκκυξ, cuckoo, resembling a cuckoo's beak) is composed of four small pieces, which form the caudal termination of the vertebral column. The superior piece is broad, and expands laterally into two transverse processes; it is surmounted by an oval articular surface and two cornua, the former to articulate with the apex of the sacrum, the latter with the sacral cornua. The lateral wings sometimes become connected with the sacrum, and convert the notches for the fifth pair of sacral nerves into foramina. The remaining three pieces diminish in size from above downwards. The borders of the bone are narrow, and give attachment to the coccygeus muscle; the inferior extremity is rounded, and has attached to it the fibres of the external sphincter ani.

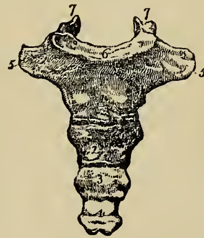


FIG. 78.- Front view of the coccyx. 1, 2, 3, 4. The four pieces of the bone. 5, 5. The transverse processes of the first piece. 6. Articular surface for the extremity of the sacrum. 7, 7. The cornua which articulate with the sacral cornua.

Development.—By *four* centres, one for each piece, but, occasionally, one of the upper three pieces has an additional centre. Ossification commences in the first piece soon after birth; in the second, between five and ten years; in the third, between ten and fifteen; and in the fourth, between fifteen and twenty. The pieces unite at an earlier period than the bodies of the sacrum, the first two pieces first, then the third and fourth, and lastly the second and

third. Between forty and sixty years, the coccyx becomes consolidated with the sacrum ; this event taking place later in the female than in the male.

Articulations.—With the sacrum.

Attachment of Muscles.—To *three* pairs, and one single muscle ; *on each side* the coccygeus, *behind* the gluteus maximus, *in front* the levator ani, *at the tip* the sphincter ani.

OF THE SKULL.

The skull is divisible into two parts, the cranium and the face ; the former being adapted, by its form, structure, and strength, to contain and protect the brain ; the latter, the chief organs of sense.

√ The CRANIUM is composed of eight separate bones—viz., the

Occipital,	Two temporal,
Two parietal,	Sphenoid,
Frontal,	Ethmoid.

OCCIPITAL BONE.

This bone is situated at the posterior part and base of the cranium. It is trapezoid in figure, and divisible into two surfaces, four borders, and four angles.

FIG. 79.—External surface of the occipital bone. 1. Superior curved line. 2. External occipital protuberance. 3. Spine. 4. Inferior curved line. 5. Foramen magnum. 6. Condyle of the right side. 7. Posterior condylar fossa, in which the posterior condylar foramen is found. 8. Anterior condylar foramen concealed by the margin of the condyle. 9. Transverse process ; this process on the internal surface of the bone forms the jugular eminence. 10. The notch in front of the jugular eminence, forming part of the jugular foramen. 11. Basilar process. 12. Rough projections into which the odontoid ligaments are inserted.

External Surface.—Is convex from above downwards and from side to side. Crossing the middle of the bone transversely, from one lateral angle to the other, is a prominent ridge, the *superior curved line.* In the middle of the ridge is a projection called the *external occipital protuberance,* for the attachment of the *ligamentum nuchæ;* and descending from it a small vertical ridge,

the *occipital spine* or *crest*. Above and below the superior curved line the surface is rough, for the attachment of muscles. About three-quarters of an inch below the superior curved line is another transverse ridge, the *inferior curved line*, and beneath the latter the *foramen magnum*. On each side of the foramen magnum, nearer its anterior than its posterior segment, and encroaching somewhat upon the opening, is an oblong articular surface, the *condyle*, for articulation with the atlas. The condyles approach towards each other anteriorly, their articular surfaces looking downwards and outwards. Directly behind each condyle is an irregular fossa, and, sometimes, a small opening, the *posterior condylar foramen*, for the transmission of a vein to the lateral sinus. In front of the condyle is the *anterior condylar foramen*, transmitting the hypoglossal nerve, and often a small meningeal artery ; on the outer side of each condyle, a projecting ridge, the *transverse process*, excavated in front by a notch which forms part of the jugular foramen ; and directly behind the ridge, and forming its posterior boundary, a prominent process, the *jugular tubercle*. In front of the foramen magnum is a thick square mass, the *basilar process*, and in its centre a small tubercle, the *pharyngeal tubercle* or *spine*, for the attachment of the tendinous raphé and superior constrictor muscle of the pharynx.

Internal Surface.—The internal surface is concave from side to side and from above downwards ; it is divided by a crucial ridge into four fossæ, the two superior or cerebral fossæ lodging the posterior lobes of the cerebrum, the two inferior or cerebellar, the lateral lobes of the cerebellum. The superior arm of the crucial ridge is grooved for the superior longitudinal sinus, and gives attachment to the falx cerebri ; the inferior arm is sharp and prominent for the attachment of the falx cerebelli, and slightly grooved for the two occipital sinuses. The transverse ridge gives attachment to the tentorium cerebelli, and is deeply grooved for the lateral sinuses. At the point of meeting of the four arms is a projection, the *internal occipital protuberance*. The convergence of the four grooves forms a slightly depressed fossa (usually situated to the left of the internal occipital protuberance), upon which rests the torcular Herophili. In the centre of the basilar portion of the bone is the *foramen magnum*, oblong in form, and larger behind than before, transmitting the spinal cord and its membranes, the spinal accessory nerves, and vertebral and posterior meningeal arteries, and having its anterior constricted portion occupied by the tip of the odontoid process of the axis. Upon the lateral margins of the foramen magnum are two rough eminences, which give attachment to the odontoid ligaments, and immediately above these, the openings of the anterior condylar foramina. In front of the foramen magnum is the basilar process, grooved on its surface for supporting the medulla oblongata, and along each lateral border for the inferior petrosal sinus. On each side of the foramen magnum is a groove, for the termination of the lateral sinus ; a smooth surface, which forms part of the jugular

fossa ; and a projecting process, which divides the two, and is called the *jugular eminence.* Into the jugular fossa will be seen opening the posterior condylar foramen.

The *superior borders* are strongly serrated, and assist in forming the lambdoidal suture ; the *inferior* are rough, not serrated, and articulate with the mastoid portion of the temporal bones. The jugular eminence and side of the basilar process articulate with the petrous portion of the temporal bone, and the intervening space, which is irregularly notched, forms the posterior boundary of the jugular foramen, or foramen lacerum posterius.

The *angles* of the occipital bone are, the superior, inferior, and

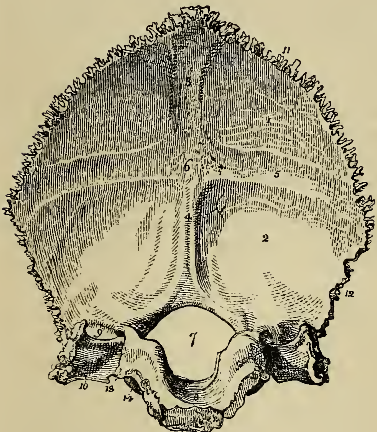
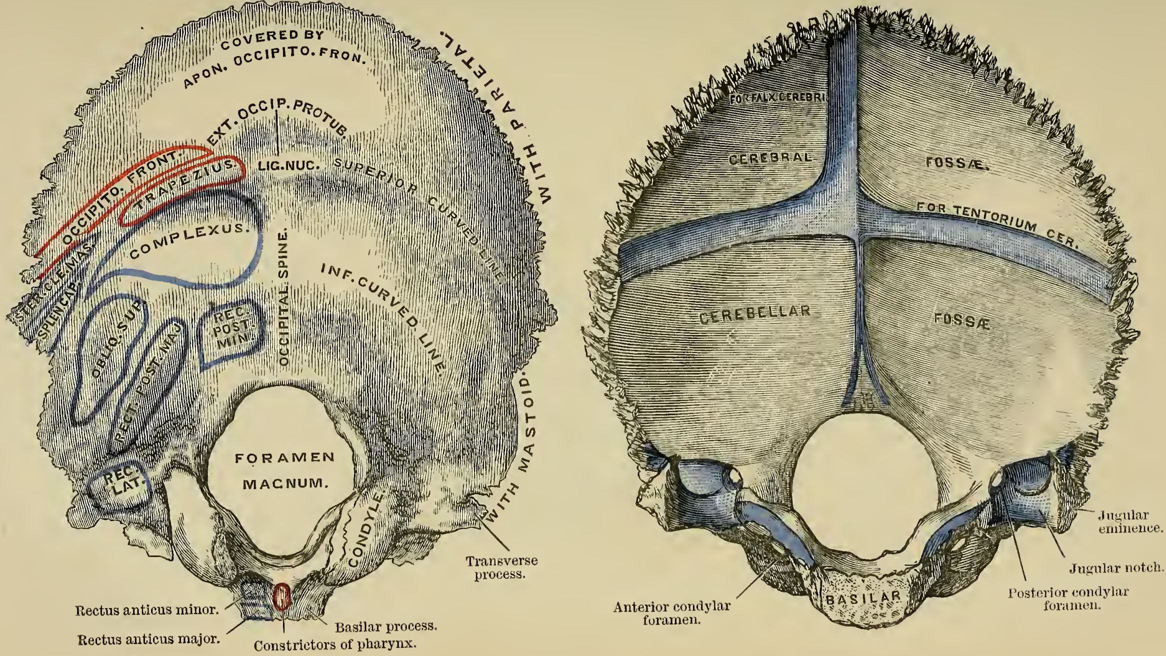


Fig. 80.—Internal surface of the occipital bone. 1. Left cerebral fossa. 2. Left cerebellar fossa. 3. Groove for the posterior part of the superior longitudinal sinus. 4. Spine for the falx cerebelli, and groove for the occipital sinuses. 5. Groove for the left lateral sinus. 6. Internal occipital protuberance. 7. Foramen magnum. 8. Basilar process, grooved for the medulla oblongata. 9. Termination of the groove for the lateral sinus, bounded externally by the jugular eminence. 10. Jugular fossa ; this fossa is completed by the petrous portion of the temporal bone. 11. Superior border. 12. Inferior border. 13. Border which articulates with the petrous portion of the temporal bone, grooved by the inferior petrosal sinus. 14. Anterior condylar foramen.

two lateral. The *superior angle* is received into the interval formed by the union of the posterior and superior angles of the parietal bones, and corresponds with that portion of the fœtal head which is called the *posterior fontanelle.* The *inferior angle* is the extremity of the basilar process, which in the adult is united with the sphenoid. The *lateral angles*, at each side, project into the interval formed by the articulation of the posterior and inferior angle of the parietal with the mastoid portion of the temporal bone.

Development.—By *seven* centres ; four for the four parts of the expanded portion divided by the crucial ridge, one for each condyle, and one for the basilar process. Ossification commences in the expanded portion of the bone during the sixth or seventh week ; at birth the bone consists of four distinct pieces, called respectively *supra-occipital*, two *ex-occipitals*, and *basi-occipital ;* the three first unite during the third or fourth year, the last joins them about the fourth to the sixth year. After twenty the basilar process unites

PLATE 1.


COVERED BY
APON. OCCIPITO. FRON.
WITH PARIETAL.
EXT. OCCIP. PROTUB.
LIG. NUC.
SUPERIOR CURVED LINE.
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TRAPEZIUS.
STER.CLE.MAS.
SPLEN.CAP.
COMPLEXUS.
OCCIPITAL SPINE.
INF. CURVED LINE.
OBLIQ. SUP.
RECT. POST. MAJ.
REC. POST. MIN.
REC. LAT.
FORAMEN MAGNUM.
CONDYLE.
WITH MASTOID.
Transverse process.
Rectus anticus minor.
Rectus anticus major.
Basilar process.
Constrictors of pharynx.
FOR FALX CEREBRI
CEREBRAL
FOSSÆ.
FOR TENTORIUM CER.
CEREBELLAR
FOSSÆ.
BASILAR
Anterior condylar foramen.
Posterior condylar foramen.
Jugular notch.
Jugular eminence.

with the body of the sphenoid. The part above the occipital protuberances is developed from membrane, the rest from cartilage.

Articulations.—With *six* bones; two parietal, two temporal, sphenoid, and atlas.

Attachment of Muscles.—To *twelve* pairs; to the *rough surface above the superior curved line*, the occipito-frontalis; to the *superior curved line*, the trapezius and sterno-mastoid; to the *rough space between the curved lines*, complexus, and splenius capitis; to the *space between the inferior curved line and the foramen magnum*, the rectus posticus major and minor, and obliquus superior; to the *transverse process*, the rectus lateralis; and to the *basilar process*, the rectus anticus major and minor, and superior constrictor of the pharynx.

PARIETAL BONE.

The parietal bone (*paries*, a wall) is situated at the side and vertex of the skull; it is quadrilateral in form, and divisible into an external and internal surface, four borders, and four angles. The

FIG. 81.—External surface of the left parietal bone. 1. Superior or sagittal border. 2. Inferior or squamous border. 3. Anterior or coronal border. 4. Posterior or lambdoidal border. 5. Temporal ridge; the figure is situated immediately in front of the parietal eminence. 6. The parietal foramen, unusually large in the bone from which this figure was drawn. 7. Anterior inferior angle. 8. Posterior inferior angle.

superior border is straight, to articulate with its fellow of the opposite side. The inferior border is arched and thin, to articulate with the temporal bone. The anterior border is concave, and the posterior somewhat convex.

External Surface.—Crossing the bone in a longitudinal direction from the anterior to the posterior border, is an arched line, the *temporal ridge*, to which the temporal fascia is attached. Beneath this in well-marked specimens, and separated from it by a very narrow interval, is a second line limiting the attachment of the temporal muscle. In the middle of these lines, and nearly in the centre of the bone, is the projection called the *parietal eminence*, which marks the centre of ossification. Above the temporal ridge the surface is rough, and covered by the aponeurosis of the occipito-frontalis; below the ridge the bone is smooth, for the attachment of the fleshy fibres of

the temporal muscle. Near the superior border of the bone, and at about one-third from its posterior extremity, is the *parietal foramen*, which transmits a vein to the superior longitudinal sinus. This foramen is often absent.

Internal Surface.—The internal table is smooth; it is marked by numerous furrows, which lodge the ramifications of the middle meningeal artery, and by irregular depressions called digital fossæ which correspond with the convolutions of the brain. Along the upper border is part of a shallow groove, completed by the opposite parietal bone, which serves to contain the superior longitudinal

FIG. 82.—Internal surface of the left parietal bone. 1. Superior, or sagittal border. 2. Inferior, or squamous border. 3. Anterior, or coronal border. 4. Posterior, or lambdoidal border. 5. Part of the groove for the superior longitudinal sinus. 6. Internal termination of the parietal foramen. 7. Anterior inferior angle of the bone, on which is seen the groove for the trunk of the middle meningeal artery. 8. Posterior inferior angle, on which is seen a portion of the groove for the lateral sinus.

sinus. Near this groove, some slight pits, which lodge the Pacchionian bodies, are also observable.

The *anterior inferior angle* is thin and lengthened, and articulates with the tip of the great wing of the sphenoid bone. Its inner surface is deeply grooved for the middle meningeal artery; the groove being frequently converted into a closed canal. The *posterior inferior angle* is thick, and presents a broad and shallow groove for the lateral sinus.

Development.—By a single centre. Ossification commences in the parietal eminence at the same time as in the bodies of the vertebræ (seventh or eighth week). The whole of this bone is developed from membrane.

Articulations.—With *five* bones; with the opposite parietal, occipital, frontal, temporal, and sphenoid.

Attachment of Muscles.—To *one* only, the temporal. The aponeurosis of the occipito-frontalis glides over its upper surface.

FRONTAL BONE.

The frontal bone bears some resemblance in form to the under valve of a scallop-shell. It is situated at the anterior part of the

cranium, forming the forehead, and assisting in the construction of the roof of the orbits and nose. Hence it is divisible into a superior or frontal portion, and an inferior or orbito-nasal portion. Each of these portions presents for examination an external and internal surface, borders, and processes.

External Surface.—At about the middle of each lateral half of the frontal portion is a projection, the *frontal eminence.* Below these points are the *superciliary ridges*, large towards their inner termination, where they become continuous with the nasal tuberosity, and becoming gradually smaller as they arch outwards: they support the eyebrows. Beneath the superciliary ridges are the sharp and prominent arches which form the upper margin of the orbits, the *supraorbital ridges.* Externally the supraorbital ridge terminates in the *external angular process*, internally in the *internal angular process;* at the inner third of this ridge is a notch, sometimes converted into

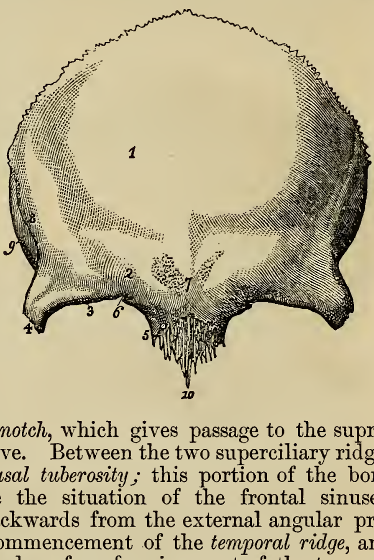


FIG. 83.—External surface of the frontal bone. 1. Situation of the frontal eminence of the right side. 2. Superciliary ridge. 3. Supraorbital ridge. 4. External angular process. 5. Internal angular process. 6. Supraorbital notch, for the transmission of the supraorbital nerve and artery. 7. Nasal tuberosity; the swelling around this point denotes the situation of the frontal sinuses. 8. Temporal ridge, commencing from the external angular process (4). 9. Part of the temporal fossa. 10. Nasal spine.

a foramen—the *supraorbital notch*, which gives passage to the supraorbital artery, veins, and nerve. Between the two superciliary ridges is a rough projection, the *nasal tuberosity;* this portion of the bone denotes by its prominence the situation of the frontal sinuses. Extending upwards and backwards from the external angular process is a sharp ridge, the commencement of the *temporal ridge*, and beneath the ridge a depressed surface, forming part of the *temporal fossa*, and giving attachment to the *temporal muscle.*

The *orbito-nasal portion* of the bone consists of two thin processes, the *orbital plates*, which form the roof of the orbits, and an intervening notch which lodges the ethmoid bone, and is called the *ethmoidal fissure.* The edges of the ethmoidal fissure are hollowed into cavities, which, by their union with the ethmoid bone, complete the ethmoidal cells. Crossing these edges transversely are two small grooves, which are converted into canals by articulation with the ethmoid:

these are the anterior and posterior ethmoidal canals; they open on the inner wall of the orbit,—the anterior transmitting the anterior ethmoidal artery and vein and nasal nerve, the posterior giving passage to the posterior ethmoidal vessels. At the anterior termination of these edges are the irregular openings which lead into the frontal sinuses; and between the two internal angular processes is a rough excavation which receives the nasal bones, and a projecting process, the *nasal spine.* On each orbital plate, immediately beneath the external angular process, is a shallow depression which lodges the lachrymal gland; and beneath the internal angular process a small pit, sometimes a tubercle, to which the cartilaginous pulley of the superior oblique muscle of the eye is attached.

Internal Surface.—Along the middle line of this surface is a *grooved ridge*, the edges of the ridge giving attachment to the falx cerebri, the groove lodging the superior longitudinal sinus. At the commencement of the ridge is an opening, sometimes completed by the ethmoid bone, the *foramen cæcum.* This opening lodges a process

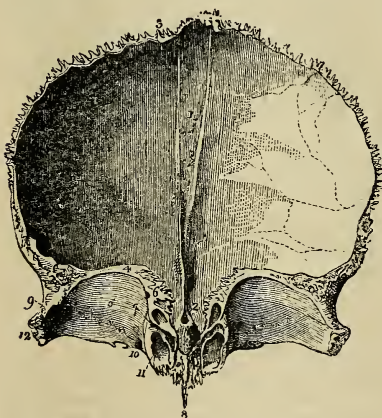
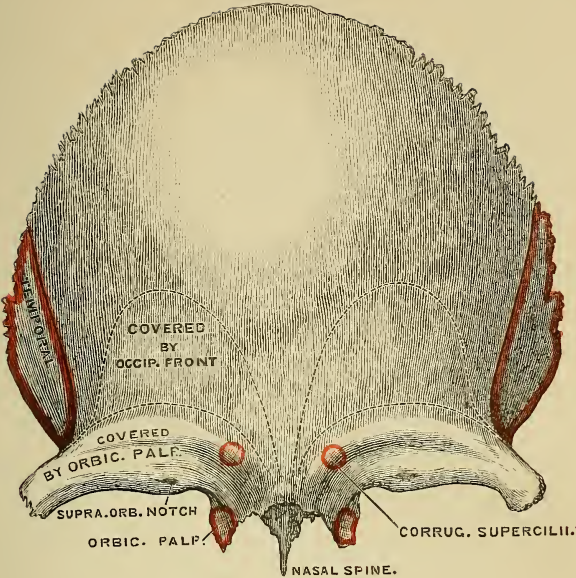


FIG. 84.—Internal surface of the frontal bone; the bone is raised to show the orbito-nasal portion. 1. Grooved ridge for the lodgment of the superior longitudinal sinus and attachment of the falx. 2. Foramen cæcum. 3. Superior or coronal border of the bone; the figure is situated near that part which is bevelled at the expense of the internal table. 4. Inferior border of the bone. 5. Orbital plate of the left side. 6. Cellular border of the ethmoidal fissure. The foramen cæcum (2) is seen through the ethmoidal fissure. 7. Anterior and posterior ethmoidal foramen; the anterior is seen leading into its canal. 8. Nasal spine. 9. The depression within the external angular process (12) for the lachrymal gland. 10. Depression for the pulley of the superior oblique muscle of the eye; immediately to the left of this number is the supraorbital notch, and to its right the internal angular process. 11. Opening leading into the frontal sinuses; the leading line crosses the internal angular process. 12. External angular process. The corresponding parts are seen on the other side of the figure.

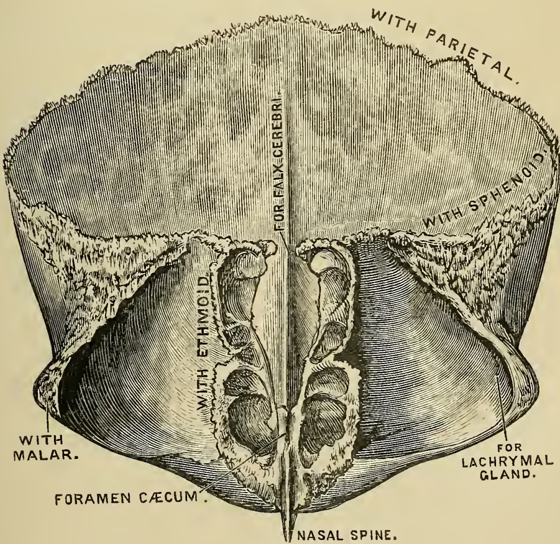
of the dura mater, and occasionally gives passage to a small vein which communicates with the nasal veins. On each side of the vertical ridge are some slight depressions which lodge the Pacchionian bodies, and on the orbital plates a number of *digital fossæ*, which correspond with the convolutions of the anterior lobes of the cerebrum.

The *superior border* is thick and strongly serrated, bevelled at the expense of the internal table in the middle, where it rests on the

PLATE 2.



TEMPORAL
COVERED BY OCCIP. FRONT
COVERED BY ORBIC. PALP.
SUPRA.ORB. NOTCH
ORBIC. PALP.
CORRUG. SUPERCILII.
NASAL SPINE.



WITH PARIETAL.
FOR FALX CEREBRI.
WITH SPHENOID.
WITH ETHMOID.
WITH MALAR.
FOR LACHRYMAL GLAND.
FORAMEN CÆCUM.
NASAL SPINE.

junction of the two parietal, and at the expense of the external table on each side where it receives the lateral pressure of those bones. The *inferior border* is thin, irregular, and squamous, and articulates with the sphenoid bone.

Development.—By *two* centres, one for each lateral half. Ossification begins in the orbital arches, somewhat before the vertebræ. The two pieces are separate at birth, and unite by suture during the first year, the suture sometimes remaining permanent through life, *frontal suture.* The frontal sinuses make their appearance during the first year, and increase in size until old age. This bone is entirely developed in membrane.

Articulations.—With *twelve* bones: two parietal, sphenoid, ethmoid, two nasal, two superior maxillary, two lachrymal, and two malar.

Attachment of Muscles.—To *three* pairs: corrugator supercilii, to the inner end of the superciliary ridge; temporal, to the temporal fossa; and orbicularis palpebrarum, to the internal angular process.

TEMPORAL BONE.

The temporal bone is situated at the side and base of the skull, and is divisible into a squamous, mastoid, and petrous portion.

The **Squamous portion** (*squama*, a scale), forming the anterior part of the bone, is thin, translucent, and contains no diploë. On its *external surface* it is smooth, gives attachment to the fleshy fibres

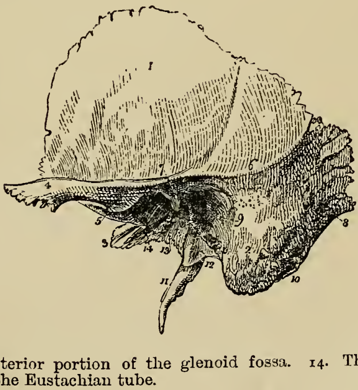


Fig. 85.—External surface of the temporal bone of the left side. 1. Squamous portion. 2. Mastoid portion. 3. Extremity of the petrous portion. 4. The zygoma. 5. Indicates the tubercle of the zygoma, and at the same time its anterior root turning inwards to form the eminentia articularis. 6. Superior root of the zygoma, forming the posterior part of the temporal ridge. 7. Middle root of the zygoma, terminating abruptly at the glenoid fissure. 8. Mastoid foramen. 9. External auditory meatus, surrounded by the auditory process. 10. The digastric fossa, situated immediately to the inner side of (2) the mastoid process. 11. Styloid process. 12. Vaginal process. 13. Fissure of Glaser; the leading line from this number crosses the rough posterior portion of the glenoid fossa. 14. The opening and part of the groove for the Eustachian tube.

of the temporal muscle, and has projecting from it an arched and lengthened process, the *zygoma* (from ζυγὸς, a yoke, because it joins the temporal and malar bones together). Near the commencement of the zygoma, upon its lower border, is a projection called the *tubercle*, to which is attached the external lateral ligament of the lower jaw,

and continued horizontally inwards from the tubercle, a rounded eminence, the *eminentia articularis.* The process of bone which is continued from the tubercle of the zygoma into the eminentia articularis is the *inferior root* of the zygoma. The *superior root* is continued upwards from the upper border of the zygoma, and forms the posterior part of the temporal ridge, serving by its projection to mark the division of the squamous from the mastoid portion of the bone; and the *middle root* is continued directly backwards, and terminates abruptly at a narrow fissure, the fissure of Glaser. The upper border of the zygoma is thin and sharp, and has attached to it the fibres of the temporal fascia; the lower border is thick, and gives origin to some fibres of the masseter muscle. The *internal surface* of the squamous portion is marked by several shallow fossæ, which correspond with the convolutions of the cerebrum, and by a furrow for the posterior branch of the middle meningeal artery. The *superior* or *squamous border* is very thin, and bevelled at the expense of the inner surface, so as to overlap the lower and arched border of the parietal bone. The *inferior border* is thick, and dentated to articulate with the spinous process of the sphenoid bone.

The **Mastoid portion** (*μαστὸς εἶδος*, nipple-like) forms the posterior part of the bone; it is thick and hollowed between its tables into numerous cavities. On its *external surface* it is rough for the attachment of muscles, and contrasts strongly with the smooth and polished surface of the squamous portion: every part of the surface is pierced by small foramina, which give passage to minute arteries and veins; one of these openings, oblique in direction, of large size, and situated near the posterior border of the bone, the *mastoid foramen*, transmits a vein to the lateral sinus, and a small artery to the dura mater. Not unfrequently this foramen is situated in the occipital bone, or is absent altogether. The inferior part of the mastoid portion is round and expanded, the *mastoid process*, and excavated in its interior into numerous cells, connected with the organ of hearing. In front of the mastoid process, and between the superior and middle root of the zygoma, is the large oval opening of the *external auditory meatus*, surrounded by a rough lip, the *auditory process.* Directly to the inner side of, and partly concealed by, the mastoid process, is a deep groove, the *digastric fossa*, for the digastric muscle, and a little more internally the *occipital groove*, which lodges the occipital artery, a branch of the external carotid. On its *internal surface* the mastoid portion presents a broad and shallow groove (*fossa sigmoidea*) for the lateral sinus, and terminating in this groove the internal opening of the mastoid foramen. The *superior border* of the mastoid portion is dentated, and articulates with the posterior inferior angle of the parietal bone; its posterior border is thick, and less serrated, and articulates with the inferior border of the occipital bone.

The **external auditory meatus** is a slightly curved canal, somewhat more than half an inch in length, longer along its lower than its upper wall, and directed obliquely inwards and forwards. The canal is narrower at the middle than at the extremities, is broadest

in its horizontal diameter, and terminates at the outer wall of the tympanum by an abrupt oval border. Within the margin of this border is a groove for the insertion of the membrani tympani.

Fig. 86.—Section of the temporal bone, right side, showing the curved direction of the external auditory meatus. 1. Edge of the auditory process. 2. Groove into which the membrana tympani is inserted. The obliquity of the line from 2 to 3 indicates the oblique termination of the meatus, and the consequent oblique direction of the membrani tympani. 4, 4. Cavity of the tympanum. 5. Opening of the Eustachian tube. 6. Part of the aquæductus Fallopii. 7. Part of the carotid canal.

The **Petrous portion** of the temporal bone is named from its extreme hardness and density (πέτρος, a rock). It is a three-sided pyramid, projecting horizontally forwards into the base of the skull, the base being applied against the internal surface of the squamous and mastoid portions, and the apex being received into the triangular interval between the spinous process of the sphenoid and the basilar process of the occipital bone. For convenience of description it is divisible into three surfaces, anterior, posterior, and basilar; and three borders, superior, anterior, and posterior.

The *anterior surface*, forming the posterior boundary of the middle fossa of the interior of the base of the skull, presents for examination from base to apex, firstly, a slight depression, which corresponds to the position of the roof of the tympanic cavity; next, an *eminence* caused by the projection of the perpendicular semicircular canal; thirdly, a groove leading to an irregular oblique opening, the *hiatus Fallopii*, for the transmission of the petrosal branch of the Vidian nerve; another and smaller oblique foramen, immediately beneath the preceding, for the passage of the lesser petrosal nerve; and lastly, a large foramen near the apex of the bone, the termination of the carotid canal.

The *posterior surface* forms the front boundary of the posterior fossa of the base of the skull; near its middle is the oblique entrance of the *meatus auditorius internus*, which gives passage to the seventh pair of nerves and the auditory artery. Above the meatus auditorius internus is a small oblique fissure, and a minute foramen; the former lodges a process of the dura mater, and the foramen gives passage to a small vein. Further outwards, towards the mastoid portion of the bone, is a small slit, almost hidden by a thin plate of bone; this is the *aquæductus vestibuli*, and transmits a small artery and vein of the vestibule and a process of dura mater. Below the meatus, and partly concealed by the margin of the posterior border of the bone, is a triangular opening, the termination of the *aquæductus cochleæ*, through which passes a vein from the cochlea to the internal jugular vein, and a process of dura mater.

The *basilar surface* of the petrous portion is rough, irregular, and enters into the formation of the under surface of the base of the skull. Projecting downwards, near its middle, is a long sharp spine, the *styloid process*, occasionally connected with the bone only by cartilage,

and lost during maceration, particularly in the young subject. At the base of this process is a rough sheath-like ridge, into which the styloid process appears implanted, the *vaginal process* or tympanic lamina; it is continuous externally with the auditory process. In front of the vaginal process is a broad triangular depression, the *glenoid fossa*, bounded in front by the eminentia articularis, behind by the vaginal process, and externally by the rough lip of the auditory process.

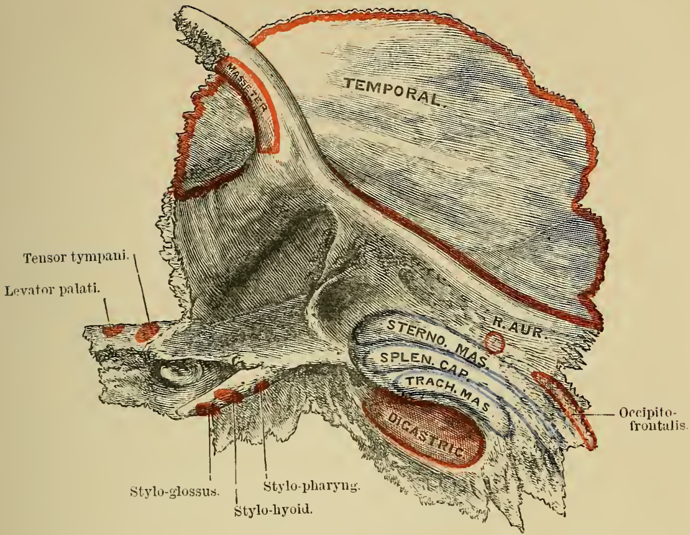
The *glenoid fossa* (γλήνη, a socket) is divided tranversely by the *fissure of Glaser*, which receives the extremity of the processus gracilis of the malleus, and transmits the laxator tympani muscle, and ante-

FIG. 87.—Left temporal bone, seen from within. 1. Squamous portion. 2. Mastoid portion. The figure is placed immediately above the inner opening of the mastoid foramen. 3. Petrous portion. 4. Groove for the posterior branch of the middle meningeal artery. 5. Bevelled edge of the squamous border of the bone. 6. Zygoma. 7. Digastric fossa, immediately internal to the mastoid process. 8. Occipital groove. 9. Groove for the lateral sinus. 10. Elevation on the anterior surface of the petrous bone, marking the situation of the perpendicular semicircular canal. 11. Opening of termination of the carotid canal. 12. Meatus auditorius internus. 13. A dotted line leads upwards from this figure to the narrow fissure which lodges a process of the dura mater. Another line leads downwards to the sharp edge which conceals the opening of the aquæductus cochleæ, while the cipher itself is situated on the bony lamina which overlies the opening of the aquæductus vestibuli. 14. Styloid process. 15. Stylo-mastoid foramen. 16. Carotid foramen. 17. Jugular process. The deep excavation to the left of this process forms part of the jugular fossa, that to the right is the groove for the eighth pair of nerves. 18. Notch for the fifth nerve on the upper border of the petrous bone, near its apex. 19. Extremity of the petrous bone; this part gives origin to the levator palati and tensor tympani muscle.

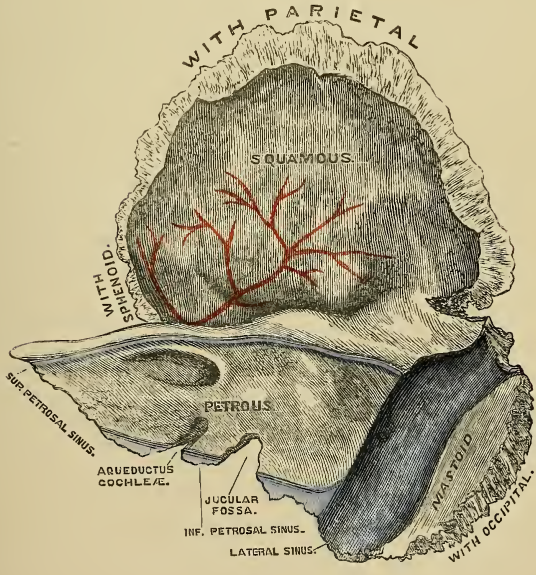
rior tympanic artery. At the inner extremity of the fissure a minute canal terminates, *canal of Huguier;* it transmits the chorda tympani nerve. The surface of the fossa in front of the fissure is smooth, to articulate with the condyle of the lower jaw; and that behind the fissure rough, for the reception of part of the parotid gland. At the extremity of the inner angle of the glenoid fossa is the foramen of the *Eustachian tube;* above this, and separated from it by a thin lamella of bone, called *processus cochleariformis*, is a small canal for the transmission of the tensor tympani muscle.

Directly behind, and at the root of the styloid process, is the *stylo-mastoid foramen*, the opening of exit of the facial nerve, and entrance of the stylo-mastoid artery; and a little in front of this, between the mastoid and vaginal processes, is a small slit, the *auricular fissure*, for the exit of the auricular branch of the pneumogastric (Arnold's nerve). Nearer the apex of the bone is a large oval opening, the

PLATE 3.



TEMPORAL.
MASSETER
Tensor tympani.
Levator palati.
R. AUR.
STERNO. MAS.
SPLEN. CAP.
TRACH. MAS.
DIGASTRIC.
Occipito-frontalis.
Stylo-glossus.
Stylo-pharyng.
Stylo-hyoid.



WITH PARIETAL
SQUAMOUS.
WITH SPHENOID.
PETROUS.
SUP. PETROSAL SINUS.
AQUEDUCTUS COCHLEÆ.
JUGULAR FOSSA.
INF. PETROSAL SINUS.
LATERAL SINUS.
MASTOID
WITH OCCIPITAL.

carotid foramen, the commencement of the carotid canal, which lodges the internal carotid artery and carotid plexus. Between the stylo-mastoid and carotid foramen, in the posterior border, is an irregular excavation forming part of the jugular fossa for the commencement of the internal jugular vein; on the inner wall of which will be found a minute foramen, for the entrance of Arnold's nerve. The share of the jugular fossa formed by the petrous portion of the temporal bone is different in different bones; but in all the fossa presents a vertical ridge on its inner side, which cuts off a small portion from the rest. The upper part of this ridge forms a spinous projection, the *jugular process*; the groove to the inner side of the ridge lodges the eighth pair of nerves, and the lower part of the ridge is the septum of division between the jugular fossa and carotid foramen. Upon the latter portion of the ridge, near the posterior margin of the carotid foramen, is a small opening leading into a canal which transmits the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal nerve.

The *superior border* of the petrous portion is sharp, and gives attachment to the tentorium cerebelli. It is grooved for the superior petrosal sinus, and near its extremity is marked by a smooth notch, upon which reclines the Gasserian ganglion of the fifth nerve. The *anterior border* is grooved for the Eustachian tube, and forms the posterior boundary of the foramen lacerum basis cranii; by its sharp extremity it gives attachment to the tensor tympani, and levator palati muscle. The *posterior border* is grooved for the inferior petrosal sinus, and excavated for the jugular fossa: it forms the anterior boundary of the foramen lacerum posterius (jugular foramen).

Development.—By four centres: one for the squamous portion, one for the petrous and mastoid portions, one for the auditory process, which in the fœtus is a mere bony ring incomplete superiorly, and serving for the attachment of the membrana tympani, *annulus membranæ tympani*; and one for the styloid process. Ossification occurs in these pieces in the following order: in the squamous portion immediately after the vertebræ, then in the tympanic, next in the petrous and mastoid, and last in the styloid. The tympanic ring is united by its extremities to the squamous portion during the last month of intra-uterine life; the squamous, petrous, and mastoid portions are consolidated during the first year; and the styloid some years after birth. It not unfrequently happens that the latter remains permanently separate, or is prolonged by a series of pieces to the os hyoides, and so completes the hyoid arch. The subsequent changes in the bone are, the increase of size of the glenoid fossa, the growth of the external auditory meatus, the levelling of the surfaces of the petrous portion, and the development of mastoid cells. Traces of the union of the petrous with the squamous portion of the bone are usually perceptible in the adult.

FIG. 88. — The annulus membranæ tympani or tympanic bone of the fœtal skull, right side.

Articulations.—With *five* bones: occipital, parietal, sphenoid, inferior maxillary, and malar.

Attachment of Muscles.—To *fourteen:* by the *squamous portion*, to the temporal; by the *zygoma*, to the masseter; by the *mastoid portion*, to the occipito-frontalis, splenius capitis, sterno-mastoid, trachelo-mastoid, digastricus, and retrahens auriculam; by the *styloid process*, to the stylo-pharyngeus, stylo-hyoid, stylo-glossus, and two ligaments, stylo-hyoid and stylo-maxillary; and by the *petrous portion*, to the levator palati, tensor tympani, and stapedius.

SPHENOID BONE.

The sphenoid (σφὴν, a wedge) is an irregular bone, situated at the base of the skull, wedged between the other bones of the cranium, and entering into the formation both of the cranium and face. It bears some resemblance, in form, to a bat with its wings extended, and is divisible into body, wings, and processes.

The **body** forms the central mass of the bone, from which the wings and processes are projected. From the upper and anterior part of the body extend, one to each side, two small triangular plates, the lesser wings; from each side, and expanding laterally, are the greater wings; proceeding backwards from the base of the greater wings, the spinous processes, and downwards, the pterygoid processes. The body presents for examination a superior or cerebral surface, an antero-inferior surface, and a posterior surface.

Superior Surface.—At the anterior extremity of this surface is a small projecting plate, the *ethmoidal spine*, and spreading out on each side the lesser wings. Behind the ethmoidal spine in the middle line is a shallow transverse groove which lodges the optic commissure; behind this a rounded elevation, the *olivary process;* and on either side of the posterior margin of that process a tubercle, the *middle clinoid process* (κλίνη, a bed). Passing outwards and forwards from the groove just mentioned are the *optic foramina*, which transmit the optic nerves and ophthalmic arteries. Behind the optic foramina are two sharp tubercles, the *anterior clinoid processes*, which are the inner terminations of the lesser wings. Beneath these processes, on the sides of the olivary process, are two depressions * for the last turn of the internal carotid arteries. Behind the olivary process is the *sella turcica*, the deep fossa which lodges the pituitary gland and circular sinus; behind and somewhat overhanging the sella turcica, is a broad rough plate (dorsum ephippii) bounded at each angle by a tubercle, the *posterior clinoid processes;* and behind this plate an inclined surface (clivus Blumenbachii), which is continuous with the basilar process of the occipital bone, and supports the Pons Varolii. On each side of the sella turcica is a broad groove (*carotid* or *caver-*

* These depressions are occasionally converted into foramina by the extension of a short bony pillar from the middle to the anterior clinoid process.

nous groove); it is bounded externally at its back part by a well-marked ridge called the *ligula*. The carotid groove lodges the internal carotid artery, cavernous sinus, orbital nerves, and cavernous plexus of the sympathetic. The nerves are contained in the walls of

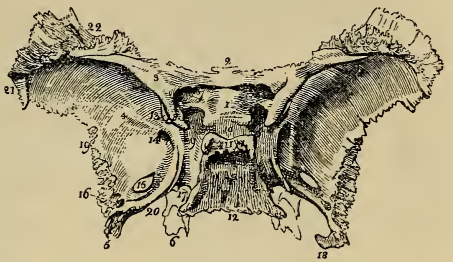


FIG. 89.—Superior or cerebral surface of the sphenoid bone. 1. Olivary process. 2. Ethmoidal spine. 3. Lesser wing of the left side. 4. Cerebral surface of the greater wing of the same side. 5. Spinous process. 6. Extremity of the pterygoid process, projecting downwards from the under surface of the body of the bone. 7. Optic foramen. 8. Anterior clinoid process. 9. Groove by the side of the sella turcica; for lodging the internal carotid artery, cavernous plexus, cavernous sinus, and orbital nerves. 10. Sella turcica; the two tubercles in front of the figure are the middle clinoid processes. 11. Posterior boundary of the sella turcica; its projecting angles are the posterior clinoid processes. 12. Basilar portion of the bone. 13. Part of the sphenoidal fissure. 14. Foramen rotundum. 15. Foramen ovale. 16. Foramen spinosum. 17. The angular interval which receives the apex of the petrous portion of the temporal bone. The posterior extremity of the Vidian canal terminates at this angle. 18. Spine of the spinous process. 19. The border of the greater wing and spinous process, which articulates with the anterior part of the squamous portion of the temporal bone. 20. The internal border of the spinous process, which assists in the formation of the foramen lacerum basis cranii. 21. That portion of the greater wing which articulates with the anterior inferior angle of the parietal bone. 22. The portion of the greater wing which articulates with the orbital process of the frontal bone.

the sinus, the sixth and cavernous plexus being in the inner wall, the third, fourth, and ophthalmic division of the fifth (in the order here given, from above downwards) in the outer wall. They are separated from the blood of the sinus by its lining membrane.

Upon the **antero-inferior surface** of the body of the sphenoid is a long flattened spine or crest, the superior part of which *sphenoidal crest* articulates with the central lamella of the ethmoid, while the inferior part, longer and sharper, the *rostrum*, is inserted into the sheath formed by the upper border of the vomer. On each side of the sphenoidal crest is an irregular opening leading into the sphenoidal cells. The sphenoidal cells, absent in the young subject, are divided by a median septum which is continuous with the crest, and are partially closed by two thin plates of bone (frequently broken away), the *sphenoidal spongy bones* (bones of Bertin). On each side of the sphenoidal cells are the outlets of the optic foramina, and other openings to be presently described; the lesser and greater wings; and, below, the pterygoid processes. At the under surface of the body are two thin plates of bone (*vaginal processes*), proceeding from the base of the pterygoid process at each side, articulating with the border of the vomer. On each of these plates, close to the root of the pterygoid process, is a groove (sometimes a canal) converted into

a canal by the palate bone, the *pterygo-palatine canal* for the pterygo-palatine nerve and artery; and traversing the root of the pterygoid process at its union with the body of the bone, is the *pterygoid or Vidian* canal, which gives passage to the Vidian nerve and artery.

The **posterior surface** of the body is flat and rough, and articulates with the basilar process of the occipital bone. In the adult this union is usually completed by bone; from which circumstance the sphenoid, in conjunction with the occipital, is described by Soemmering and Meckel as a single bone, under the name of *spheno-occipital.* The posterior surface is continuous at each side with the spinous process, and in the angle of union is the termination of the Vidian canal.

The **lesser wings** (processes of Ingrassias) are thin and triangular, the base being attached to the upper and anterior part of the body of the sphenoid; and the apex, prolonged outwards, terminating in an acute point. The anterior border is irregularly serrated, the

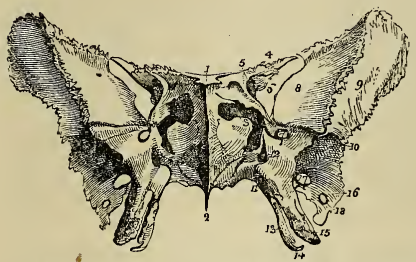
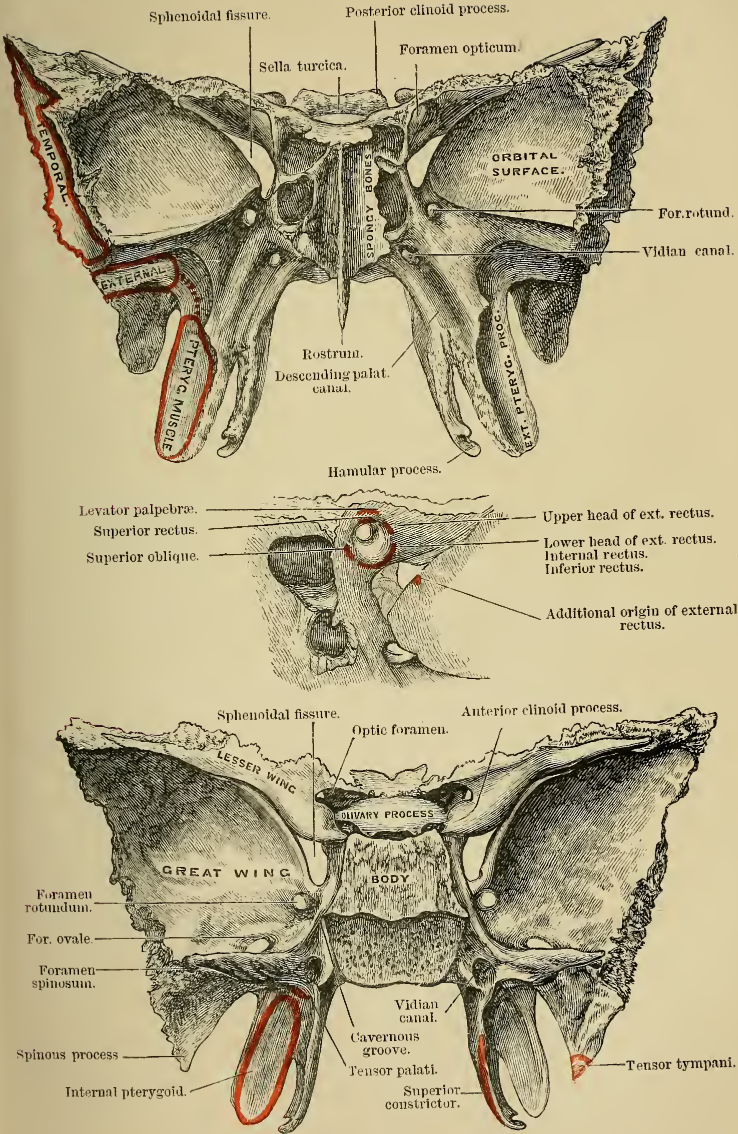


FIG. 90.—Antero-inferior view of the sphenoid bone. 1. Ethmoid spine. 2. The rostrum. 3. Sphenoidal spongy bone, partly closing the left opening of the sphenoidal cells. 4. Lesser wing. 5. Optic foramen, piercing the base of the lesser wing. 6. Sphenoidal fissure. 7. Foramen rotundum. 8. Orbital surface of the greater wing. 9. Its temporal surface. 10. The pterygoid ridge. 11. Pterygo-palatine canal. 12. Foramen of entrance of the Vidian canal. 13. Internal pterygoid plate. 14. Hamular process. 15. External pterygoid plate. 16. Foramen spinosum. 17. Foramen ovale. 18. Extremity of the spinous process of the sphenoid.

posterior being free and rounded, and received into the fissure of Sylvius of the cerebrum. The inner extremity of this border is the anterior clinoid process; it is supported by a short pillar of bone, which forms the inferior boundary of the optic foramen, and gives attachment by its anterior surface to part of the common tendon of the muscles of the orbit. The lesser wing forms the posterior part of the roof of the orbit. Between the lesser and greater wings is a triangular slit, broad internally, but narrowing almost to a point at its outer extremity—this is the *sphenoidal fissure;* it transmits the third, fourth, three branches of the ophthalmic division of the fifth, and sixth nerves, with the ophthalmic vein.

The **greater wings** present three surfaces; a superior or cerebral, which forms part of the middle fossa of the base of the skull; an anterior surface, which assists in forming the outer wall of the orbit; and an external surface, divided into two parts by the *pterygoid ridge.* The superior surface is concave, and receives the anterior part of the middle lobe of the cerebrum; at its internal border, where the

PLATE 4.


Sphenoidal fissure.
Posterior clinoid process.
Foramen opticum.
Sella turcica.
TEMPORAL.
ORBITAL SURFACE.
SPONGY BONES
For. rotund.
Vidian canal.
EXTERNAL
PTERYG. MUSCLE
EXT. PTERYG. PROC.
Rostrum.
Descending palat. canal.
Hamular process.
Levator palpebræ.
Superior rectus.
Superior oblique.
Upper head of ext. rectus.
Lower head of ext. rectus.
Internal rectus.
Inferior rectus.
Additional origin of external rectus.
Sphenoidal fissure.
Anterior clinoid process.
Optic foramen.
LESSER WING
OLIVARY PROCESS
GREAT WING
BODY
Foramen rotundum.
For. ovale.
Foramen spinosum.
Vidian canal.
Cavernous groove.
Spinous process
Tensor palati.
Tensor tympani.
Internal pterygoid.
Superior constrictor.

greater wing joins the body, and immediately behind the sphenoidal fissure, is a circular opening, *foramen rotundum*, through which passes the superior maxillary branch of the fifth nerve. Behind this, but nearer to the external border, a large foramen pierces the root of the spinous process: this is called *foramen ovale;* it transmits the inferior maxillary division of the fifth nerve, the small meningeal artery, and lesser petrosal nerve. At the inner side of the foramen ovale a small opening is sometimes found; it is the *foramen Vesalii*, and transmits a small vein. The anterior surface looks into the orbit; it is quadrilateral in shape, and its posterior border, which bounds the sphenoidal fissure inferiorly, is usually marked by a slight prominence, for the attachment of part of the external rectus muscle; its inferior edge forms the outer boundary of the spheno-maxillary fissure. The superior part of the external surface enters into the formation of the temporal fossa, the inferior portion forms part of the zygomatic fossa. The pterygoid ridge, dividing the two, gives attachment to the upper origin of the pterygoideus externus muscle.

The **spinous processes** are the posterior terminations of the greater wings; they project backwards, and are received into the angular interval between the squamous and petrous portions of the temporal bones. Near its apex each process is pierced by a small opening, *foramen spinosum*, for the middle meningeal artery, and extending downwards from the apex is a short spine, which gives attachment to the long internal lateral ligament of the lower jaw, and to the laxator tympani muscle. The external border of the spinous process is rough, to articulate with the lower border of the squamous portion of the temporal bone; the internal border forms the anterior boundary of the foramen lacerum basis cranii, and is somewhat grooved for the reception of the Eustachian tube.

The **pterygoid processes** descend perpendicularly from the base of the greater wings, and form in the articulated skull the lateral boundaries of the posterior nares. Each process consists of an external and internal plate, and an anterior surface. The *external plate* is broad and thin, giving attachment, by its external surface, to the external pterygoid muscle, and by its internal surface to the internal pterygoid. The *internal pterygoid plate* is long and narrow, terminating at its extremity by a curved hook, the *hamular process*, around which plays the tendon of the tensor palati muscle, and to the tip of which the pterygo-maxillary ligament is attached; while from the lower third of its posterior border some fibres of the superior constrictor muscle of the pharynx have their origin. At the base of the internal pterygoid plate is a small oblong depression, the *scaphoid fossa*, from which arises the circumflexus or tensor palati muscle. The interval between the two pterygoid plates is the *pterygoid fossa;* and the two plates are separated inferiorly by an angular notch (*palatine*) which receives the tuberosity, or *pterygoid process*, of the palate bone. The *anterior surface* of the pterygoid process is broad near its base; it forms the posterior wall of the spheno-maxillary

fossa, and supports Meckel's ganglion. At its lower part this surface is slightly grooved, to form part of the posterior palatine canal. The base of the pterygoid process is pierced by the Vidian canal.

Development.—Up to the seventh or eighth month of intra-uterine existence, the anterior and posterior parts of the body of the sphenoid are distinct from each other;—the anterior part, extending from the posterior border of the olivary process to the ethmoidal spine, being called *pre-sphenoid*, and the posterior portion, from the border of the olivary process to the spheno-occipital synchondrosis, the *post-sphenoid.*

The sphenoid is developed by *fourteen* centres of ossification, four for the pre-sphenoid, six for the post-sphenoid, two for the internal pterygoid plates, and two for the sphenoidal spongy bones. The first pre-sphenoidal centres appear at the outer side of the optic foramina, about the eighth or ninth week. These are soon followed by another pair of centres, placed to the inner side of the optic foramina. From these four centres the anterior part of the body of the sphenoid and the lesser wings are developed. About the eighth week ossific nuclei appear in the greater wings, between the foramen ovale and rotundum. From this point ossification extends into the whole of the great wing and the external pterygoid plate. In the eighth week also, or a little later, two centres appear in the post-sphenoidal portion of the body, placed side by side in the bottom of the sella turcica. These unite about the fourth month, and after their union two new centres spring up at the outer side of the carotid groove, and form the ligula. The centres for the internal pterygoid processes appear about the fourth month, and they unite with the external pterygoid about the sixth month. The sphenoidal spongy bones do not become ossified till after birth; they join the rest of the bone at the time of puberty.

At the time of birth the sphenoid consists of three pieces—the body in the centre, and on each side the great wings with the external pterygoid plates. They unite during the first year. The sphenoid joins the occipital from the eighteenth to the twenty-fifth year.

Articulations.—With *twelve* bones: that is, with all the bones of the head, and five of the face—viz., two malar, two palate, and vomer.

Attachment of Muscles.—To *twelve* pairs: temporal, external pterygoid, internal pterygoid, superior constrictor, tensor palati, laxator tympani, levator palpebræ, obliquus superior, superior rectus, internal rectus, inferior rectus, and external rectus.

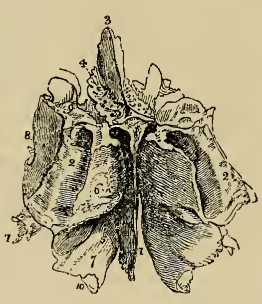
ETHMOID BONE.

The ethmoid (ἠθμὸς, a sieve) is a square-shaped cellular bone, situated between the two orbits, at the root of the nose, and perforated on its upper surface by a number of small openings, from

which peculiarity it has received its name. It consists of a perpendicular lamella and two lateral masses.

The **perpendicular lamella** is a thin central plate, which articulates by its anterior border with the frontal spine and crest of the nasal bones, and by its posterior border with the crest of the sphenoid and upper edge of the vomer. It assists in forming the septum of the nose. It is surmounted superiorly by a thick and strong process, the *crista galli*, which projects into the cavity of the skull, and gives attachment to the falx cerebri. From the base of the anterior border of this process there project forward two small plates, *alar processes*, which are received into corresponding depressions in the frontal bone, and often complete posteriorly the foramen cæcum. At each side of the crista galli, on the upper surface of the bone, is a thin and grooved lamella perforated with a number of small openings, the *cribriform plate* which supports the bulb of the olfactory

FIG. 91.—Ethmoid bone seen from above and behind. 1. Perpendicular lamella. 2, 2. Lateral masses; the figures are placed on the posterior border of the lateral mass at each side. 3. Crista galli. 4. Cribriform plate of the left side, pierced by its foramina. 5. The hollow space immediately above and to the left of this number is the superior meatus. 6. Superior turbinated bone. 7. Middle turbinated bone; the numbers, 5, 6, 7, are situated on the internal surface of the left lateral mass, near its posterior parts. 8. External surface of the lateral mass, or os planum. 9. Superior or frontal border of the lateral mass, grooved by the anterior and posterior ethmoidal canals. 10. Refers to the concavity of the middle turbinated bone, which is the upper boundary of the middle meatus. 11. Unciform process.



nerve, and gives passage to its filaments; in front of it is a small slit for the nasal branch of the ophthalmic nerve. In the middle of the groove of the cribriform plate the foramina pierce the bone completely, but at each side they are the apertures of canals which run for some distance in the substance of the central lamella, inner wall of the lateral mass, and spongy bones. The cribriform plate serves to connect the lateral masses with the perpendicular plate. It articulates by its posterior border with the ethmoidal spine of the sphenoid.

The **lateral masses** are divisible into an internal and external surface, and four borders, superior, inferior, anterior, and posterior.

The **internal surface** is rough, slightly convex, and forms the external boundary of the upper part of the nasal fossæ. Towards the posterior border of this surface is a narrow horizontal fissure, the *superior meatus* of the nose; the upper margin of this fissure is thin, and somewhat curled inwards, hence it is named the *superior turbinated bone.* Below the meatus is the convex surface of another thin plate, which is curled outwards, and forms the lower border of the mass, the *middle turbinated bone.* The *external surface* is

quadrilateral and smooth; hence it is named *os planum;* it enters into the formation of the inner wall of the orbit.

The **superior border** is uneven and cellular, the cells being completed by the edges of the ethmoidal fissure of the frontal bone. This border is crossed by two grooves, sometimes complete canals, opening into the orbit by the anterior and posterior ethmoidal foramina. The **inferior border** is formed internally by the lower border of the middle turbinated bone, and externally by a concave irregular fossa, the upper boundary of the middle meatus. The **anterior border** presents a number of incomplete cells, which are closed by the superior maxillary and lachrymal bone; the **posterior border** is irregularly cellular, to articulate with the sphenoid and palate bone. From the anterior part of each lateral mass an irregular plate of bone descends backwards, terminating in a hook-like extremity: this is called the *unciform process.* It assists in closing the orifice of the antrum, and articulates with the ethmoidal process of the inferior turbinated bone.

The lateral masses are composed of cells, divided by a thin partition into anterior and posterior ethmoidal cells. The anterior, the most numerous, communicate with the frontal sinuses, and open by means of an irregular and incomplete tubular canal, the *infundibulum*, into the middle meatus. The posterior cells, fewer in number, open into the superior meatus.

Development.—By *three* centres: one for each lateral mass, and one for the perpendicular lamella. Ossification commences in the lateral masses at about the beginning of the fifth month, appearing first in the os planum, and then in the spongy bones. At birth the bone merely consists of two ill-developed lateral masses. During the latter half of the first year after birth, the central lamella and cribriform plate begin to ossify, and are united to the lateral masses by the beginning of the second year. The cells of the ethmoid are developed in the course of the fourth and fifth year.

Articulations.—With *thirteen* bones: two of the cranium, frontal and sphenoid; and eleven of the face, viz., two nasal, two superior maxillary, two lachrymal, two palate, two inferior turbinated, and vomer.

No muscles are attached to this bone.

BONES OF THE FACE.

The face is composed of fourteen bones—namely,

Two nasal,	Two palate,
Two superior maxillary,	Two inferior turbinated,
Two lachrymal,	Vomer,
Two malar,	Inferior maxillary.

NASAL BONES.

The nasal are two small quadrangular bones, forming by their union the bridge and base of the nose. They are convex on their outer surface, and pierced by a foramen for a small vein ; on the inner surface they are somewhat concave, and marked by a groove which lodges the nasal branch of the ophthalmic nerve. The superior border is narrow and thick, the inferior broad, thin, and irregular. The anterior border, thick above and thin below, articulates with the bone of the opposite side. The external border is thin and irregular ; it is bevelled at the expense of the inner surface above, and of the outer surface below, and articulates with the nasal process of the superior maxillary.

FIG. 92.—Nasal bone of the left side ; its external or convex surface. 1. Superior border. 2. Internal or mesial border. 3. External border. 4. Inferior or free border. 5. Foramen for a small vein.

Development.—By a *single* centre for each bone, the first ossific deposition making its appearance at the same time as in the vertebræ.

Articulations.—With *four* bones : frontal, ethmoid, nasal, and superior maxillary.

Attachment of Muscles.—It has in relation with it the pyramidalis nasi and compressor nasi ; but neither is inserted into it.

SUPERIOR MAXILLARY BONES.

The superior maxillary are the largest bones of the face, with the exception of the lower jaw ; they form, by their union, the whole of the upper jaw, and assist in the construction of the nose, orbit, cheek, and palate. Each bone is divisible into a body and four processes.

The **body** is triangular in form, and hollowed in its interior into a large cavity, the *antrum maxillare* (antrum of Highmore). It presents for examination four surfaces, external or facial, internal or nasal, posterior or zygomatic, and superior or orbital.

The **external** or **facial surface** forms the anterior part of the bone ; it is irregularly concave, and presents a deep depression towards its centre, the *canine fossa*, which gives attachment to the *levator anguli oris* muscle. Immediately above this fossa is the *infraorbital foramen*, the termination of the infraorbital canal, transmitting the infraorbital nerve and artery ; and above the infraorbital foramen is the lower margin of the orbit, continuous externally with the rough articular surface of the malar process, and internally with a thick ascending plate, the nasal process. Between the infraorbital foramen and the margin of the orbit, the *levator labii superioris*

proprius muscle has its origin. Towards the middle line of the face the external surface is bounded by the concave border of the opening of the nose; this border is projected forwards at its inferior termination into a sharp process, forming, with a similar process of the opposite bone, the *nasal spine.* Beneath the nasal spine, and above the two superior incisor teeth, is a slight depression, the *incisive* or *myrtiform fossa*, which gives origin to the *depressor labii superioris alœque nasi* muscle. Above and a little to the outer side of the fossa the compressor nasi has its origin. The myrtiform fossa is divided

FIG. 93.—Superior maxillary bone of the right side, as seen on its lateral aspect. 1. External or facial surface; the depression in which the cipher is placed is the canine fossa. 2. Posterior, or zygomatic surface. 3. Superior or orbital surface. 4. Infraorbital foramen, situated immediately below the cipher. 5. Infraorbital canal, leading to the infraorbital foramen. 6. Inferior border of the orbit. 7. Malar process. 8. Nasal process. 9. Lateral boundary of the anterior nares. 10. Nasal spine. 11. Incisive or myrtiform fossa. 12. Alveolar process. 13. The internal border of the orbital surface, which articulates with the ethmoid and palate bone. 14. Concavity which articulates with the lachrymal bone, and forms the commencement of the nasal duct. 15. Nasal crest of the palate process. *i.* Two incisor teeth. *c.* Canine. *b.* Two bicuspid teeth. *m.* Three molars.

from the canine fossa by a perpendicular ridge, corresponding with the root of the canine tooth. The inferior boundary of the facial surface is the alveolar process which contains the teeth of the upper jaw; and the facial is separated from the zygomatic surface by a strong projecting eminence, the *malar process.*

The **internal** or **nasal surface** presents a large irregular opening, leading into the antrum; this opening is nearly closed in the articulated skull by the ethmoid, palate, lachrymal, and inferior turbinated bone. The cavity of the antrum is somewhat triangular, corresponding in shape with the form of the body of the bone; the base of the triangle being directed towards the nose, and the apex towards the malar bone. On its inner wall are numerous grooves, lodging branches of the superior maxillary nerve, and projecting into its floor several conical processes, corresponding with the roots of the first and second molar teeth. In front of the opening of the antrum is the strong ascending plate of the nasal process, marked inferiorly by a rough horizontal ridge (crista turbinalis inferior), which gives attachment to the inferior turbinated bone. The concave depression immediately above this ridge corresponds with the middle meatus of the nose, that below the ridge with the inferior meatus. Between the nasal process and the opening of the antrum is a deep vertical groove (sulcus lachrymalis), converted into a canal by the lachrymal and inferior turbinal bone, and constituting the nasal duct. The *supe-*

rior border of the nasal surface is irregularly cellular, and articulates with the lachrymal and ethmoid bone; the *posterior border* is rough, and articulates with the palate bone; the *anterior border* is sharp, and forms the free margin of the opening of the nose, and, from the *inferior border*, projects inwards a strong horizontal plate, the *palate process.*

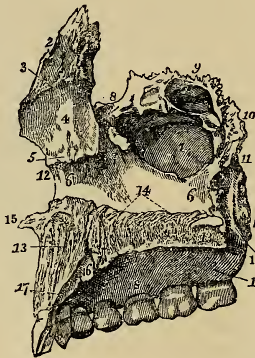


FIG. 94.—Right superior maxillary bone; internal surface. 1. Antrum. 2. Nasal process. 3. Crista turbinalis superior. 4. Depression corresponding with the middle meatus. 5. Crista turbinalis inferior. 6, 6. Inferior meatus. 7. Lachrymal groove. 8. Notch for articulation with the lachrymal bone. 9. Superior border of the bone, in which are seen three ethmoidal cells. 10, 10. Posterior border; the lower 10 marks the articulating surface for the palate bone. 11, 11. Groove of the posterior palatine canal. 12. Anterior border of the bone. 13, 13. Palate process. 14. Nasal crest. 15. Nasal spine. 16. Anterior palatine canal. 17. Situation of the incisive foramen. 18, 18. Alveolar process.

The **posterior surface** may be called *zygomatic*, as forming part of the zygomatic fossa; it is bounded externally by the malar process, and internally by a rough and rounded border, the *tuberosity*, which is pierced by a number of small foramina, giving passage to the posterior dental nerves and branches of the superior dental artery. The lower part of this tuberosity presents a rough oval surface, to articulate with the palate bone, and immediately above and to the inner side of this articular surface a smooth groove, which forms part of the posterior palatine canal. The *superior border* is smooth and rounded, forming the lower boundary of the spheno-maxillary fissure, and marked by a notch, the commencement of the infraorbital canal. The *inferior* boundary is the alveolar process, containing the last two molar teeth.

The **orbital surface** is triangular and thin, and constitutes the floor of the orbit. It is bounded internally by an irregular edge, which articulates with the palate, ethmoid, and lachrymal bone; posteriorly, by the smooth border which enters into the formation of the spheno-maxillary fissure; and, anteriorly, by a convex margin, partly smooth and partly rough, the smooth portion forming part of the lower border of the orbit, the rough portion articulating with the malar bone. The middle of this surface is channelled by a deep groove and canal, the infraorbital, which terminates at the infraorbital foramen; and near the root of the nasal process is a slight depression, marking the origin of the *inferior oblique* muscle of the eyeball.

The *four processes* of the superior maxillary bone are, the nasal, malar, alveolar, and palate.

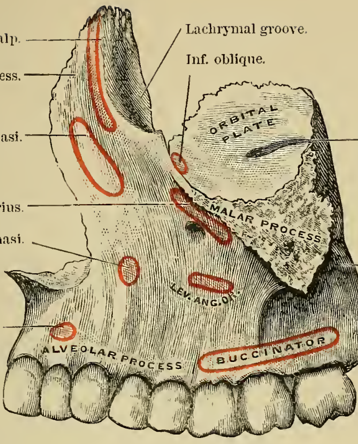
The **nasal process** ascends by the side of the nose, to which it forms the lateral boundary, and articulates with the frontal and nasal bone. By its *external surface* it gives attachment to the *levator labii superioris alæque nasi*, and to the *orbicularis palpebrarum* muscle. Its *internal surface* contributes to form the outer wall of the nares, and is marked transversely by a horizontal ridge (crista turbinalis superior), which divides it into two portions, one above the ridge irregular and uneven, for giving attachment to and completing the cells of the lateral mass of the ethmoid; the other below, smooth and concave, corresponding with the middle meatus. The *posterior border* is thick and grooved for the nasal duct; while the prominent margin in front of that groove is continuous with the lower border of the orbit; this margin is marked by a small *tubercle*, which serves as a guide to the introduction of the knife in opening into the lachrymal sac.

The **malar process**, large and irregular, is situated at the angle of separation between the facial and zygomatic surface, and presents a triangular surface for articulation with the malar bone.

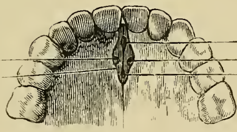
The **alveolar process** forms the lower margin of the bone; it is spongy and cellular in texture, and excavated into deep holes for the reception of eight teeth. By its outer surface, as far forwards as the first molar tooth, it gives origin to the *buccinator* muscle. The anterior portion of its process containing the sockets of the incisor teeth, together with a small portion of the palate process, has a separate centre of ossification, and in the lower animals it remains separate throughout life as the *intermaxillary* or *premaxillary* bone. In young human skulls, a fissure running backwards from the outer edge of the second incisor nearly to the incisive foramen, indicates the line of junction of the premaxillary bone with the rest of the maxilla; and in cases of cleft palate (there being an arrest of development) this portion is present as a distinct bone.

The **palate process** is thick and strong, and projects horizontally inwards from the inner surface of the body of the bone. *Superiorly*, it is concave and smooth, and forms the floor of the nares; *inferiorly*, it is also concave, but uneven, and assists in the formation of the roof of the palate. The latter surface is marked by a deep groove, which lodges the anterior palatine nerve and artery. Its internal edge is raised into a ridge (*nasal* or *palate crest*), which, with a corresponding ridge in the opposite bone, forms a groove for the reception of the vomer. The prolongation of this ridge forwards beyond the level of the facial surface of the bone is the *nasal spine*. Near the anterior extremity of the internal border is seen a deep groove, which, expanding inferiorly, forms with its fellow of the opposite side the *incisive foramen*. When the hard palate (completed by the junction of the two bones) is viewed from below, this foramen is seen to contain four smaller foramina, two of which are placed in the middle line, one before the other (foramina of Scarpa), the other two (foramina of Stenson) being placed laterally. These all open above into

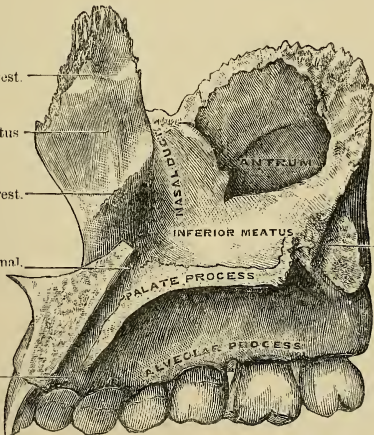
PLATE 5.



Orbic. palp.
Nasal process.
Lev. lab. sup. alæque nasi.
Lev. proprius.
Compressor nasi.
Depressor alæ nasi.
Lachrymal groove.
Inf. oblique.
Infraorbital canal.
Zygomatic process.
ORBITAL PLATE
MALAR PROCESS
LEV. ANG. OR.
ALVEOLAR PROCESS
BUCCINATOR



Anterior palatine canal.
Incisive foramen.
Anterior naso-palatine canal.
Anterior palatine canal.
Posterior naso-palatine canal.



Sup. turbinal crest.
Middle meatus
Inf. turbinal crest.
Ant. palat. canal.
Incisive foramen
Desc. palat. canal.
NASAL DUCT
ANTRUM
INFERIOR MEATUS
PALATE PROCESS
ALVEOLAR PROCESS

the inferior meatus of the nose, the first pair (Scarpa's) transmitting the naso-palatine nerves, the nerve of the left side occupying the anterior foramen, and that of the right side (the larger of the two) the posterior. The other foramina are the inferior terminations of the *anterior palatine canals;* they give passage to the anterior palatine arteries.

Development.—By *four* centres: one for the anterior part of the palate and incisive portion of the alveolar process (intermaxillary); one for that portion of the bone lying internally to the infraorbital canal and foramen; one for that portion lying externally to the infraorbital groove and canal; and one for the palate process. The antrum first begins to be formed about the fourth month of fœtal life. The superior maxillary bone is one of the earliest to show signs of ossification, this action beginning in the alveolar process, and being associated with the early development of teeth. The early development of the alveolar process, and the consequent fusion at this point of the original pieces, explains the difficulties which have been felt by anatomists in determining the precise number of ossifying centres of the bone.

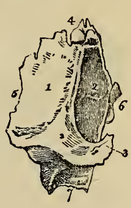
Articulations.—With *nine* bones; viz., two of the cranium, and all the bones of the face, excepting the inferior maxillary. These are, frontal and ethmoid; nasal, lachrymal, malar, inferior turbinated, palate, vomer, and its fellow of the opposite side.

Attachment of Muscles.—To *ten:* orbicularis palpebrarum, obliquus inferior oculi, levator labii superioris alæque nasi, levator labii superioris proprius, levator anguli oris, compressor nasi, dilatator naris, depressor alæ nasi, buccinator, masseter.

LACHRYMAL BONES.

The lachrymal (called os unguis, from an imagined resemblance to a finger-nail) is a thin oval-shaped plate of bone, situated in front

Fig. 95.—Lachrymal bone of the right side viewed on its external or orbital surface. 1. Orbital portion of the bone. 2. Lachrymal portion; the prominent ridge between these two portions is the crest. 3. Lower termination of the crest, the hamulus lachrymalis. 4. Superior border, which articulates with the frontal bone. 5. Posterior border, which articulates with the ethmoid bone. 6. Anterior border, which articulates with the superior maxillary bone. 7. The border which articulates with the inferior turbinated bone.



and at the inner angle of the orbit. It may be divided into an external and internal surface and four borders. The *external surface* is smooth and marked by a vertical ridge, the *lachrymal crest,* into two portions, one of which is flat and enters into the formation of the orbit, hence may be called the orbital portion; the other is concave, and lodges the lachrymal sac, hence the lachrymal portion.

The crest is expanded inferiorly into a hook-shaped process (hamulus lachrymalis), which forms part of the outer boundary of the lachrymal fossa. The *internal surface* is uneven, and completes the anterior ethmoid cells; it assists also in forming the wall of the nasal fossæ and nasal duct. The four borders articulate with adjoining bones.

Development.—By a single centre, appearing in the early part of the third month.

Articulations.—With *four* bones; two of the cranium, frontal and ethmoid; and two of the face, superior maxillary and inferior turbinated bone.

Attachment of Muscles.—To *one* muscle, the tensor tarsi, and to an expansion of the tendo oculi, the former arising from the orbital surface, the other being attached to the lachrymal crest.

MALAR BONES.

The malar (os jugale) is the strong quadrangular bone which forms the prominence of the cheek. It is divisible into an external and internal surface, and four processes, frontal, orbital, maxillary, and zygomatic. The *external surface* is smooth and convex; it gives origin to the zygomaticus major and minor muscles, and is pierced by several small openings, which give passage to filaments of the temporo-malar nerve and minute arteries. The *internal surface* is concave, partly smooth and partly rough; smooth where it forms

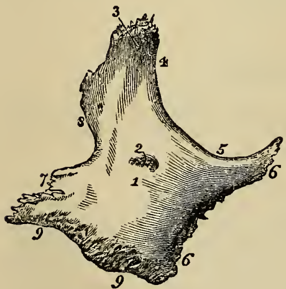


Fig. 96.—Malar bone of the right side. 1. External surface. 2. Opening for an artery and nerve. 3. Frontal process. 4. Outer border of the orbit. 5. Inferior border of the orbit. 6, 6. Maxillary process. 7. Zygomatic process. 8. Sweep to which the temporal fascia is attached. 9, 9. Lower border of the bone, from which the masseter muscle arises.

part of the temporal fossa, and rough where it articulates with the superior maxillary bone. In well-marked bones a foramen is found opening from the orbital surface into the temporal fossa; it transmits the temporal branch of the orbital nerve and the orbital branch of the temporal artery.

The *frontal process* ascends perpendicularly to form the outer border of the orbit, and articulates with the external angular process of the frontal bone. The *orbital process* is a thick plate, which projects inwards from the frontal process, and unites with the great wing

of the sphenoid to constitute the outer wall of the orbit. The *maxillary process* is broad, and articulates with the superior maxillary bone. The *zygomatic process*, narrower than the rest, projects backwards to unite with the zygoma of the temporal bone. The lower border of the bone is strong and rough; it gives attachment by its internal aspect to the masseter muscle.

Development.—By a single centre: in rare instances by two or three. In many animals the malar bone is permanently divided into two portions, orbital and malar. Ossification commences in the malar bone soon after the vertebræ.

Articulations.—With *four* bones: three of the cranium, frontal, temporal, and sphenoid; and one of the face, superior maxillary.

Attachment of Muscles.—To *five:* levator labii superioris proprius, zygomaticus minor and major, masseter, and temporal.

PALATE BONES.

The palate bones are situated at the posterior part of the nares, where they enter into the formation of the palate, side of the nose, and posterior part of the floor of the orbit; hence they might be named the palato-naso-orbital bones. Each bone resembles in general form the letter L, and is divisible into a horizontal plate, a perpendicular plate, and a pterygoid process or tuberosity.

The **horizontal plate** is quadrilateral; and presents two surfaces, one superior, which enters into the formation of the floor of the nares, the other inferior, forming the posterior part of the hard palate. The *superior surface* is concave, and rises towards the middle line, where it unites with its fellow of the opposite side and forms

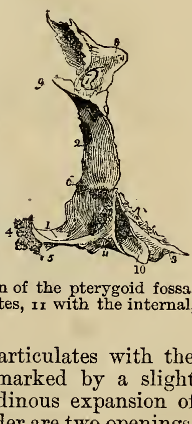


Fig. 97.—Posterior view of the right palate bone in its natural position; it is slightly turned on one side, to obtain a sight of the internal surface of the perpendicular plate (2). 1. Horizontal plate of the bone; its upper or nasal surface. 2. Perpendicular plate; its internal or nasal surface. 3, 10, 11. Pterygoid process or tuberosity. 4. Internal border of the horizontal plate, which, articulating with the similar border of the opposite bone, forms the nasal crest for the reception of the vomer. 5. The pointed process, which, with a similar process of the opposite bone, forms the palate spine. 6. The horizontal ridge which gives attachment to the inferior turbinated bone; the concavity below this ridge enters into the formation of the inferior meatus, the concavity (2) above the ridge into that of the middle meatus. 7. Spheno-palatine notch. 8. Orbital portion. 9. Crista turbinalis superior for the middle turbinated bone. 10. The smooth surface of the tuberosity, which enters into the formation of the pterygoid fossa. The facets 11 and 3 articulate with the two pterygoid plates, 11 with the internal, 3 with the external.

part of a crest (*nasal* or *palate crest*), which articulates with the vomer. The *inferior surface* is uneven, and marked by a slight transverse ridge, to which is attached the tendinous expansion of the tensor palati muscle. Near its external border are two openings,

one large and one small, the *posterior palatine foramina;* they are the terminations of two minute canals, and transmit the descending palatine artery and nerves. The posterior border is concave, and presents at its inner extremity a sharp point, which, with a corresponding point in the opposite bone, constitutes the *palate spine* for the attachment of the azygos uvulæ muscle.

The **perpendicular plate** is also quadrilateral; and presents two surfaces, one internal or nasal, forming part of the wall of the nares; the other external, bounding the spheno-maxillary fossa and antrum. The *internal surface* is marked near its middle by a horizontal ridge (crista turbinalis inferior), to which is united the inferior turbinated bone; and, about half an inch above this, by another ridge (crista turbinalis superior), for the attachment of the middle turbinated bone. The concave surface below the inferior ridge is the lateral boundary of the inferior meatus of the nose; that between the two ridges corresponds with the middle meatus, and the surface above the superior ridge with the superior meatus. The *external surface*, extremely irregular, is rough on each side for articulation with neighbouring bones, and smooth in the middle to constitute the inner boundary of the spheno-maxillary fossa. This smooth surface terminates inferiorly in a deep groove, which, being completed by the tuberosity of the superior maxillary bone and pterygoid process of the sphenoid, forms the *posterior palatine canal.*

FIG. 98.—Perpendicular plate of the right palate bone, seen on its external or spheno-maxillary surface. 1. The rough surface of this plate, which articulates with the superior maxillary bone and bounds the antrum. 2. Posterior palatine canal; completed by the tuberosity of the superior maxillary bone and pterygoid process. The rough surface to the left of the canal (2) articulates with the internal pterygoid plate. 3. Spheno-palatine notch. 4, 5, 6. Orbital portion of the perpendicular plate. 4. Spheno-maxillary surface of this portion. 5. Orbital surface. 6. Maxillary surface, to articulate with the superior maxillary bone. 7. Sphenoidal portion of the perpendicular plate. 8. Pterygoid process or tuberosity of the bone.

Near the upper part of the perpendicular plate is a large oval notch completed by the sphenoid, the *spheno-palatine foramen*, which transmits the superior nasal and naso-palatine nerves and spheno-palatine artery, and serves to divide the upper extremity of the bone into two portions, an anterior or orbital, and a posterior or sphenoidal portion. The *orbital portion* is hollow within, and presents five surfaces externally, three articular and two free; the three articular are, anterior, which looks forward and articulates with the superior maxillary bone, internal with the ethmoid, and posterior with the sphenoid. The free surfaces are, superior or orbital, which forms the posterior part of the floor of the orbit; and external, which looks into the spheno-maxillary fossa.

The **sphenoidal portion**, much smaller than the orbital, has three surfaces, two lateral and one superior. The external lateral surface enters into the formation of the spheno-maxillary fossa; the internal lateral forms part of the lateral boundary of the nares; the superior surface articulates with the under part of the body of the sphenoid bone, and assists the sphenoidal spongy bones in closing the sphenoidal sinuses. This portion takes part in the formation of the pterygo-palatine canal.

The **pterygoid progress** or **tuberosity** of the palate bone is the thick and rough process which stands backwards from the angle of union of the horizontal with the perpendicular portion of the bone. It is received into the angular fissure, which exists between the two plates of the pterygoid process at their inferior extremity, and presents three surfaces: one concave and smooth, which forms part of the pterygoid fossa, and gives origin to some fibres of the internal pterygoid muscle; and one at each side to articulate with the pterygoid plates. The anterior face of this process is rough, and articulates with the superior maxillary bone.

Development.—By a single centre, which appears in the angle of union between the horizontal and perpendicular portion, at the same time as ossification in the vertebræ.

Articulations.—With *six* bones: two of the cranium, sphenoid and ethmoid; and four of the face, superior maxillary, inferior turbinated, vomer, and the palate bone of the opposite side.

Attachment of Muscles.—To *four:* tensor palati, azygos uvulæ, internal and external pterygoid.

INFERIOR TURBINATED BONES.

The inferior turbinated or spongy bone, is a thin layer of light and porous bone, attached to the crista turbinalis inferior of the inner wall of the nares, and projecting inwards towards the septum narium. It is somewhat triangular in form, one angle being directed upwards and the curved base downwards; and slightly curled upon itself, so as to bear some resemblance to one valve of a bivalve shell, hence its

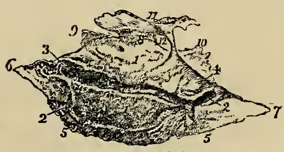


FIG. 99.—Inferior turbinated bone of the right side. 1, 1. Its internal or convex surface. 2, 2, 3. Canal for a branch of the spheno-palatine artery, dividing into two deep grooves. The figure 3 also denotes the anterior border of the bone. 4. Posterior border. 5, 5. Inferior border. 6. Anterior angle. 7. Posterior angle. 8. Superior angle. 9. Lachrymal process. 10. Ethmoidal process. 11. A large irregular process, appertaining to the ethmoidal process, and articulating with the ethmoid bone. 12. An opening into the antrum.

designation, *concha inferior.* The bone presents for examination two surfaces, internal and external; three borders, anterior, superior, and inferior; and three angles, anterior, posterior, and superior. The *internal* or *convex surface* looks inwards and upwards, and forms

the inferior boundary of the middle meatus of the nose; it is marked by one or two longitudinal grooves or canals for branches of the nasal nerves and spheno-palatine artery. The *external* or *concave surface* looks downwards and outwards, and constitutes the roof of the inferior meatus. The *anterior border* looks upwards and forwards, is thin and somewhat concave, and articulates with the crista turbinalis of the superior maxillary and with the lachrymal bone. The *superior border*, long and uneven, articulates with the crista turbinalis of the palate bone, and with the superior maxillary. The *inferior border* is convex, rounded, and free, and thicker than the rest of the bone. The *anterior angle*, attached to the superior maxillary bone, advances forward nearly to the anterior margin of the nares. The *posterior angle*, sharp and pointed, is prolonged backwards on the internal pterygoid plate. The *superior angle*, more or less rounded, gives origin to three thin and laminated processes. The most anterior of these processes, *lachrymal process*, derived from the upper extremity of the anterior border, articulates with the lachrymal bone; it is grooved on the external aspect and assists in completing the nasal duct. The posterior process, *ethmoidal process*, derived directly from the superior angle or border, often from both, articulates with the unciform process of the ethmoid bone; the middle process, *maxillary process*, proceeding also from the superior border, is reflected downwards, and assists in completing the inner wall of the antrum, articulating with the superior maxillary and palate bone.

Development.—By a single centre, which appears at about the fifth month of fœtal life.

It affords no attachment to muscles.

Articulations.—With *four* bones: ethmoid, superior maxillary, lachrymal, and palate.

VOMER.

The vomer is a thin, quadrilateral plate of bone, forming the posterior and inferior part of the septum of the nares.

The *superior border* is broad and expanded, to articulate, in the

Fig. 100.—The vomer viewed on its left aspect. 1, 1. Its superior border, with the two alæ. 2, 2. Inferior border. 3. Posterior border. 4, 4. That portion of the anterior border which articulates with the central lamella of the ethmoid. 5, 5. Inferior portion of the anterior border, which unites with the cartilage of the septum. 6, 6. An elevation on the bone marking its point of separation into two layers; the two layers are seen along the whole length of the anterior border from 4 to the lower 5.

middle, with the under surface of the body of the sphenoid; it has projecting on each side a horizontal process or *ala*, by means of

which it articulates with the vaginal processes of the sphenoid. The anterior part of this border is hollowed into a sheath for the reception of the rostrum of the sphenoid. The *inferior border* is thin and uneven, and is received into the grooved summit of the nasal or palate crest of the superior maxillary and palate bones. The *posterior border* is sharp and free, and forms the posterior division of the two nares. The *anterior border* is more or less deeply grooved for the reception of the central lamella of the ethmoid and the cartilage of the septum. This groove is an indication of the early constitution of the bone of two lamellæ, united at the inferior border. The lateral surfaces are smooth and marked by small furrows for vessels; each has a groove which runs downwards and forwards, giving passage to the naso-palatine nerve, and terminates inferiorly at the upper opening of the anterior palatine canal. The vomer not unfrequently presents a convexity to one or the other side; generally, it is said, to the left.

Development.—By a single centre, which makes its appearance at the same time with those of the vertebræ. Ossification begins from below and proceeds upwards. At birth, the vomer presents the form of a trough, in the concavity of which the cartilage of the septum nasi is placed; it is this disposition which subsequently enables the bone to embrace the rostrum of the sphenoid.

The vomer has no muscles attached to it.

Articulations.—With *six* bones: sphenoid, ethmoid, two superior maxillary, two palate; and the cartilage of the septum.

INFERIOR MAXILLARY BONE.

The lower jaw is the arch of bone which contains the inferior teeth; it is divisible into a horizontal portion or body, and a perpendicular portion, the ramus, at each side.

The **body** is divisible into two portions. That above the mental foramen (*alveolar*) is of spongy texture, and contains the sockets for the teeth—that below this foramen (*basilar*) is thick and rounded; it is dense in structure, and is marked by ridges for the attachment of muscles. The relative proportion of these two parts varies with the age of the individual: in childhood, in consequence of containing the two sets of teeth, the alveolar portion is large, and the mental foramen is near the lower border of the bone; in old age, on the contrary, from the loss of teeth and consequent absorption of the alveolar process, the basilar portion alone remains, and the mental foramen is situated near its upper border. In adult age the alveolar and basilar portions are of equal depth, the mental foramen being situated midway between the upper and lower border.

Upon the **external surface** of the *body*, at the middle line, and extending from between the two first incisor teeth to the chin, is a slight ridge, *crista mentalis*, which indicates the point of conjunction of the lateral halves of the bone in the young subject, the *symphysis*.

Immediately external to this ridge is a depression which gives origin to the depressor labii inferioris muscle; and, corresponding with the root of the lateral incisor tooth, another depression, the *incisive fossa*, for the levator labii inferioris. Farther outwards is an oblique opening, the *mental foramen*, for the exit of the mental nerve and inferior dental artery; and below this foramen, the commencement of an oblique ridge, which runs upwards and outwards to the base of the coronoid process, and gives attachment to the depressor anguli oris. Near the posterior part of this surface is a rough impression made by the masseter muscle; and, immediately in front of this impression, a groove for the facial artery. The external surface of the lower border of the bone gives attachment to some fibres of the platysma myoides muscle. The buccinator muscle arises from the base of the alveolar process as far forwards as the first molar tooth. The projecting tuberosity at the posterior extremity of the lower jaw, at the point where the body and ramus meet, is the *angle.*

Upon the **internal surface** of the *body* of the bone, at the symphysis, are two small pointed tubercles (*genial tubercles*); immediately beneath these, two other tubercles, less marked; beneath them, a ridge, and beneath the ridge two depressions of some size. These four points give attachment, from above downwards, to the genio-hyo-glossi, genio-hyoidei, part of the mylo-hyoidei, and digastric muscles. Running outwards into the body of the bone

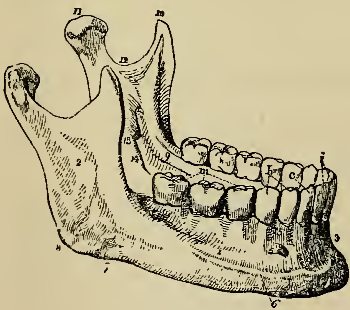
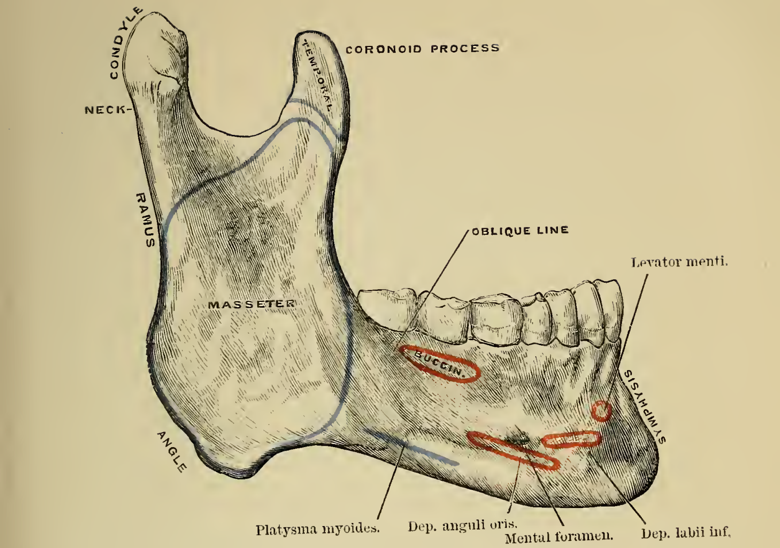


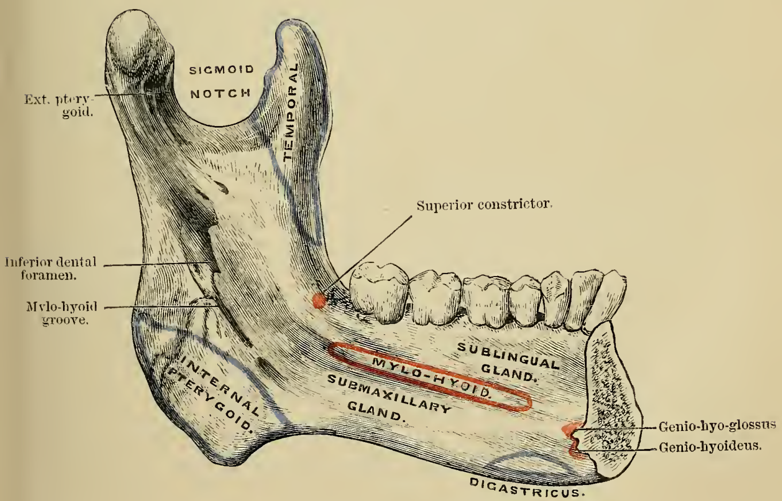
FIG. 101.—The lower jaw. 1. Body. 2. Ramus. 3. Symphysis. 4. Fossa for the depressor labii inferioris muscle. 5. Mental foramen. 6. External oblique ridge. 7. Groove for the facial artery; the situation of the groove is marked by a notch in the bone a little in front of the figure. 8. The angle. 9. Extremity of the mylo-hyoidean ridge. 10. Coronoid process. 11. Condyle. 12. Sigmoid notch. 13. Inferior dental foramen. 14. Mylo-hyoidean groove. 15. Alveolar process. *i.* Middle and lateral incisor tooth of one side. *c.* Canine tooth. *b.* Two bicuspids. *m.* Three molars.

from the above ridge is a prominent line, the *mylo-hyoidean ridge*, which gives attachment to the mylo-hyoid muscle; above its posterior termination, and near the margin of the alveolar process, the superior constrictor muscle and pterygo-maxillary ligament have their attachment. Immediately above the ridge, and by the side of the symphysis, is a smooth concave surface, which corresponds with the sublingual gland; and below the ridge, and more externally, a deeper fossa for the submaxillary gland.

The **superior border** of the body of the bone is the alveolar process, furnished in the adult with alveoli for sixteen teeth. The

PLATE 6.


CONDYLE
CORONOID PROCESS
TEMPORAL
NECK
RAMUS
OBLIQUE LINE
Levator menti.
MASSETER
BUCCIN.
SYMPHYSIS
ANGLE
Platysma myoides.
Dep. anguli oris.
Mental foramen.
Dep. labii inf.


SIGMOID
NOTCH
Ext. ptery-
goid.
TEMPORAL
Superior constrictor.
Inferior dental
foramen.
Mylo-hyoid
groove.
SUBLINGUAL
GLAND.
MYLO-HYOID.
SUBMAXILLARY
GLAND.
INTERNAL
PTERYGOID.
Genio-hyo-glossus
Genio-hyoideus.
DIGASTRICUS.

inferior border or base is rounded and smooth; thick and everted in front to form the chin, and thin behind where it merges into the angle of the bone.

The **ramus** is a strong square-shaped process, differing in direction at various periods of life; thus, in the fœtus and infant, it is almost parallel with the body; in youth it is oblique, and gradually approaches the vertical direction until manhood; in old age, after the loss of the teeth, it again declines, and assumes the oblique direction. On its external surface it is rough, for the attachment of the masseter muscle; and at the junction of its posterior border with the body of the bone it has a rough tuberosity, the *angle* of the lower jaw, which gives attachment by its inner margin to the stylo-maxillary ligament.

The upper extremity of the ramus presents two processes, separated by a concave sweep, the *sigmoid notch*. The anterior is the *coronoid process*; it is sharp and pointed, and gives attachment to the temporal muscle. The posterior process is the *condyle*, which is flattened from before backwards, oblique in direction, and smooth on its upper surface, to articulate with the glenoid cavity of the temporal bone. The constriction around the base of the condyle is its *neck*, into the external aspect of which is attached the external lateral ligament. The sigmoid notch is crossed by the masseteric artery and nerve.

The *internal surface* of the ramus is marked near its centre by a large oblique foramen, the *inferior dental*, for the entrance of the inferior dental artery and nerve into the dental canal. Bounding this opening is a sharp margin, to which is attached the internal lateral ligament, and passing downwards from the opening a narrow groove which lodges the mylo-hyoidean nerve with a small artery and vein. To the uneven surface above and in front of the inferior dental foramen is attached the temporal muscle, and to that below it, the internal pterygoid. A fossa on the anterior part of the neck of the condyle gives attachment to the external pterygoid muscle.

Development.—By *two* centres; one for each lateral half, the two sides meeting at the symphysis, where they become united. The lower jaw is the earliest of the bones of the skeleton to exhibit ossification, with the exception of the clavicle; ossific union of the symphysis takes place during the first year.

Articulations.—With the glenoid fossæ of the two temporal bones, through the medium of a fibro-cartilage.

Attachment of Muscles.—To *fifteen* pairs: by the *external surface*, commencing at the symphysis and proceeding outwards, levator labii inferioris, depressor labii inferioris, depressor anguli oris, platysma myoides, a few fibres of the orbicularis oris, buccinator, and masseter; by the *internal surface*, also commencing at the symphysis, the genio-hyo-glossus, genio-hyoid, mylo-hyoid, digastric, superior constrictor, temporal, external pterygoid, and internal pterygoid.

TABLE SHOWING THE POINTS OF DEVELOPMENT, ARTICULATIONS, AND ATTACHMENT OF MUSCLES OF THE BONES OF THE HEAD.

	Development.	*Articulation.*	*Attachment of Muscles.*
Occipital	7	6	12 pairs.
Parietal	1	5	1 muscle.
Frontal	2	12	3 pairs.
Temporal	4	5	14 muscles.
Sphenoid	14	12	12 pairs.
Ethmoid	3	13	none.
Nasal	1	4	none.
Superior maxillary	4	9	10 muscles.
Lachrymal	1	4	1 ib.
Malar	1	4	5 ib.
Palate	1	6	4 ib.
Inferior turbinated	1	4	none.
Vomer	1	6	none.
Lower jaw	2	2	15 pairs.

SUTURES.

The bones of the cranium and face are connected with each other by means of sutures (*sutura*, a seam), of which there are four principal varieties; serrated, squamous, harmonia, and schindylesis.

The **serrated suture** is formed by the union of two borders possessing serrated edges, as in the coronal, sagittal, and lambdoidal sutures. In these sutures the serrations are formed almost wholly by the external table, the edges of the internal table lying merely in apposition.

The serrated suture is formed by the interlocking of the radiating fibres along the edges of the flat bones of the cranium during growth. When this process is retarded by over-distension of the head, as in hydrocephalus, and sometimes without any such apparent cause, distinct ossific centres are developed in the interval between the edges: and, being surrounded by the suture, form independent pieces which are called *ossa triquetra*, or ossa Wormiana. In the lambdoidal suture there is generally one or more of these bones; and in an adult hydrocephalic skeleton in the College of Surgeons, there are upwards of one hundred.

The **squamous suture** (*squama*, a scale) is formed by the overlapping of the bevelled edges of two contiguous bones, as in the articulation between the temporal and lower border of the parietal. In this suture the approximated surfaces are roughened, so as to adhere mechanically with each other.

The **harmonia suture** (*ἁρεῖν*, to adapt) is the simple apposition of contiguous surfaces, the surfaces being more or less rough and retentive. This suture is seen in the connection between the superior

maxillary bones, or of the palate processes of the palate bones with each other.

The **schindylesis suture** (σχινδύλησις, a fissure) is the reception of one bone into a sheath or fissure of another, as occurs in the articulation of the rostrum of the sphenoid with the vomer, or of the latter with the perpendicular lamella of the ethmoid, and with the nasal crest of the superior maxillary and palate bones.

The **coronal suture** (fig. 102) extends transversely across the vertex of the skull, from the upper part of the greater wing of the sphenoid of one side to the same point on the opposite side; it connects the frontal with the parietal bones. In the formation of this suture the edges of the articulating bones are bevelled, so that the parietal rest on the frontal at each side, and in the middle the frontal rests on the parietal bones; they thus afford to each other mutual support and increased consolidation to the skull.

The **sagittal suture** extends longitudinally backwards along the vertex of the skull, from the middle of the coronal to the apex of the lambdoidal suture. It is much serrated, and serves to unite the two parietal bones. In the young subject, and sometimes in the adult, this suture is continued through the middle of the frontal bone to the root of the nose, under the name of *frontal suture.* Ossa triquetra are sometimes found in the sagittal suture.

The **lambdoidal suture** is named from some resemblance to the Greek letter lambda (Λ), consisting of two branches, which diverge at an acute angle from the extremity of the sagittal suture. This suture connects the occipital with the parietal bones. At the posterior and inferior angle of the parietal bones, the lambdoidal suture is continued onwards in a curved direction to the base of the skull, and serves to unite the occipital bone with the mastoid portion of the temporal. It is in the lambdoidal suture that ossa triquetra occur most frequently.

The **squamous suture** (fig. 102) unites the squamous portion of the temporal bone with the greater ala of the sphenoid and with the parietal, overlapping the lower border of the latter. The portion of the suture which is continued backwards from the squamous portion of the bone to the lambdoidal suture, and connects the mastoid portion with the posterior inferior angle of the parietal, is the *masto-parietal suture.*

Across the upper part of the face is an irregular suture, the **transverse**, which connects the frontal bone with the nasal, superior maxillary, lachrymal, ethmoid, sphenoid, and malar bones. The remaining sutures are not sufficiently important to deserve particular names or description.

REGIONS OF THE SKULL.

The skull, considered as a whole, is divisible into four regions: a superior region or vertex; a lateral region; an inferior region or base; and an anterior region, the face.

The **superior region**, or vertex of the skull, is bounded anteriorly by the frontal eminences; on each side by the temporal ridge and parietal eminence; and behind by the superior curved line of the occipital bone and occipital protuberance. It is crossed transversely by the coronal suture, and marked from before backwards by the sagittal, which terminates posteriorly in the lambdoidal suture. Near the posterior extremity of the region, and on each side of the sagittal suture, is the parietal foramen.

On the *inner* or *cerebral surface* of this region is a shallow groove extending along the middle line from before backwards, for the superior longitudinal sinus; at each side of this groove are several small fossæ for the Pacchionian bodies, and farther outwards, digital fossæ corresponding with the convexities of the convolutions, and numerous ramified grooves for lodging the branches of the meningeal arteries.

The **lateral region** of the skull is divisible into three portions; temporal, mastoid, and zygomatic.

The *temporal portion* or *temporal fossa* is bounded above and behind by the temporal ridge, in front by the external angular process of the frontal and by the malar bone, and below by the zygoma. It is formed by part of the frontal, great wing of the sphenoid, parietal,

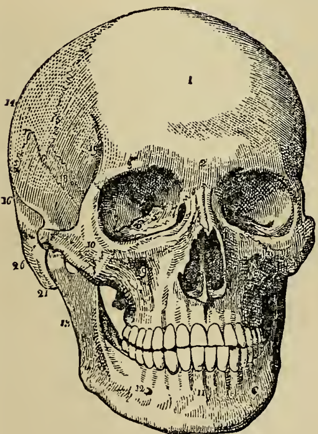


Fig. 102.—Front view of the skull. 1. Frontal portion of the frontal bone. The 2 immediately over the root of the nose refers to the nasal tuberosity; the 3 over the orbit to the supraorbital ridge. 4. Optic foramen. 5. Sphenoidal fissure. 6. Spheno-maxillary fissure. 7. The commencement of the nasal duct. The figures 4, 5, 6, 7, are within the orbit. 8. Opening of the anterior nares, divided into two parts by the vomer; the figure is placed upon the latter. 9. Infraorbital foramen. 10. Malar bone. 11. Symphysis of the lower jaw. 12. Mental foramen. 13. Ramus of the lower jaw. 14. Parietal bone. 15. Coronal suture. 16. Temporal bone. 17. Squamous suture. 18. Upper part of the great wing of the sphenoid bone. 19. Commencement of the temporal ridge. 20. Zygoma. 21. Mastoid process.

squamous portion of the temporal, malar bone, and zygoma, and is crossed by five sutures, the transverse of the face, coronal, squamous, spheno-parietal, and squamo-sphenoidal; it lodges the temporal muscle with the deep temporal arteries and nerves.

The *mastoid portion* is rough, for the attachment of muscles. On its posterior part is the mastoid foramen; and below, the mastoid process. In front of the mastoid process is the external auditory

foramen, surrounded by the external auditory process; and in front of this foramen the glenoid cavity, bounded above by the middle root of the zygoma, and in front by the eminentia articularis.

The *zygomatic portion*, or *fossa*, is the irregular cavity below the zygoma, bounded in front by the superior maxillary bone, internally by the external pterygoid plate, above by part of the great wing of the sphenoid, squamous portion of the temporal bone, and temporal fossa; and externally by the zygomatic arch and ramus of the lower jaw. It contains the external pterygoid, part of the temporal, and internal pterygoid muscle; and the internal maxillary artery and inferior maxillary nerve, with their branches. At the inner side and upper part of the zygomatic fossa are two fissures, spheno-maxillary and pterygo-maxillary. The *spheno-maxillary fissure*, horizontal in direction, opens into the orbit, and is situated between the great wing of the sphenoid and the superior maxillary bone. It is completed externally by the malar bone. The *pterygo-maxillary fissure* is vertical, and descends at a right angle from the extremity of the preceding. It is situated between the pterygoid process and the tuberosity of the superior maxillary bone, and transmits the internal maxillary artery. At the angle of junction of these two fissures is a small space, the *spheno-maxillary fossa*, bounded by the sphenoid, palate, and superior maxillary bone. In this space are seen the openings of five foramina: foramen rotundum, spheno-palatine, pterygo-palatine, posterior palatine, and Vidian. The spheno-maxillary fossa lodges Meckel's ganglion and the termination of the internal maxillary artery.

The **base of the skull** presents an internal or cerebral, and an external or basilar, surface.

The *cerebral surface* is divisible into three parts, which are named anterior, middle, and posterior fossa of the base of the cranium. The *anterior fossa* is somewhat convex at each side, where it corresponds with the roof of the orbits; and concave in the middle, in the situation of the ethmoid bone and anterior part of the body of the sphenoid. The latter and the free edges of the lesser wings constitute its posterior boundary. It supports the anterior lobes of the cerebrum. In the middle line of this fossa, at its anterior part, is the *crista galli;* immediately in front of that process, the *foramen cœcum;* and on each side, the *cribriform plate* with its *foramina*, for the transmission of the filaments of the olfactory nerve, and a slit for the nasal branch of the ophthalmic nerve. Farther back in the middle line is the olivary process, and, at the sides of this process, the *optic foramina*, *anterior* and *middle clinoid processes*, and vertical *grooves* for the internal carotid arteries.

The *middle fossa* of the base, deeper than the preceding, is bounded in front by the lesser wing of the sphenoid; behind, by the upper border of the petrous portion of the temporal bone; and is divided into two lateral parts by the sella turcica. It is formed by the posterior part of the body, great wing, and spinous process of the sphenoid, and by the petrous and squamous portion of the temporal

bones. In the centre of this fossa is the *sella turcica*, which lodges the pituitary gland, bounded in front by the *anterior* and *middle*, and behind by the *dorsum ephippii* and *posterior clinoid processes.* On each side of the sella turcica is the *carotid groove* for the internal carotid artery, cavernous plexus of nerves, cavernous sinus, and orbital nerves; and farther outwards the following foramina, from

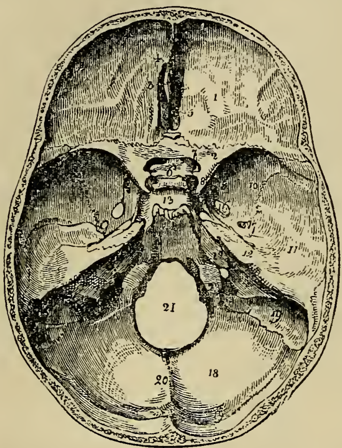


FIG. 103.—Cerebral surface of the base of the skull. 1. One side of the anterior fossa; the figure is placed on the roof of the orbit, formed by the orbital plate of the frontal bone. 2. Lesser wing of the sphenoid. 3. Crista galli. 4. Foramen cæcum. 5. Cribriform plate of the ethmoid. 6. Olivary process. 7. Optic foramen. 8. Anterior clinoid process. 9. Carotid groove on the side of the sella turcica, for the internal carotid artery and cavernous sinus. 10, 11, 12. Middle fossa of the base of the skull. 10 marks the great wing of the sphenoid. 11. Squamous portion of the temporal bone. 12. Petrous portion of the temporal. 13. Sella turcica. 14. Basilar portion of the sphenoid and occipital bone (clivus Blumenbachii). The uneven ridge between Nos. 13, 14, is the dorsum ephippii, and the prominent angles of this ridge the posterior clinoid processes. 15. Foramen rotundum. 16. Foramen ovale. 17. Foramen spinosum; the small irregular opening between 17 and 12 is the hiatus Fallopii. 18. Posterior fossa of the base of the skull. 19, 19. Groove for the lateral sinus. 20. Ridge on the occipital bone, which gives attachment to the falx cerebelli. 21. Foramen magnum. 22. Meatus auditorius internus. 23. Jugular foramen.

before backwards: *sphenoidal fissure* (foramen lacerum anterius) for the transmission of the third, fourth, three branches of the ophthalmic division of the fifth, and the sixth nerve, and ophthalmic vein; *foramen rotundum*, for the superior maxillary nerve; *foramen ovale*, for the inferior maxillary nerve, lesser meningeal artery, and lesser petrosal nerve; *foramen spinosum*, for the middle meningeal artery; *foramen lacerum basis cranii*, which is crossed by the internal carotid artery, carotid plexus, and petrosal branch of the Vidian nerve. On the anterior surface of the petrous portion of the temporal bone is a groove, leading to a fissured opening, the *hiatus Fallopii*, for the petrosal branch of the Vidian nerve; and immediately beneath this a smaller foramen, for the lesser petrosal nerve. Towards the apex of the petrous portion is the notch for the fifth nerve, and below it a slight depression for the Gasserian ganglion. Farther outwards is the eminence which marks the position of the perpendicular semicircular canal. Proceeding from the foramen spinosum are two grooves, which indicate the course of the trunks of the middle meningeal artery. The whole fossa lodges the middle lobes of the cerebrum.

The *posterior fossa*, larger than the other two, is formed by the occipital bone, petrous and mastoid portion of the temporals, and by a small part of the sphenoid and parietals. It is bounded in front by the upper border of the petrous portion and dorsum ephippii, and along its posterior circumference by the groove for the lateral sinuses; it gives support to the pons Varolii, medulla oblongata, and cerebellum. In the centre of this fossa is the *foramen magnum*, bounded at each side by a rough tubercle, which gives attachment to the odontoid ligament, and by the anterior condylar foramen. In front of the foramen magnum is the concave surface (clivus Blumenbachii) which supports the medulla oblongata and pons Varolii, and on each side the following foramina, from before backwards. The *internal auditory foramen*, for the auditory and facial nerve and auditory artery; behind, and externally to this, is a small foramen leading into the *aquæductus vestibuli*; and below it, partly concealed by the edge of the petrous bone, the *aquæductus cochleæ*; next, a long fissure, the *foramen lacerum posterius* or jugular foramen, partially divided into two by the jugular spine, the outer portion giving passage to the commencement of the internal jugular vein, and the inner to the eighth pair of nerves. Converging towards this foramen from behind is the deep groove of the lateral sinus, and from the front the groove for the inferior petrosal sinus.

Behind the foramen magnum is a longitudinal ridge, which gives attachment to the falx cerebelli, and divides the two inferior fossæ of the occipital bone; and above the ridge is the internal occipital protuberance, the transverse groove lodging the lateral sinus, and the transverse ridge giving attachment to the tentorium cerebelli.

The *external surface* of the base of the skull is extremely uneven. From before backwards it is formed by the palate processes of the superior maxillary and palate bones; the vomer; pterygoid, spinous processes, and part of the body of the sphenoid; under surface of the squamous, petrous, and mastoid portion of the temporals; and by the occipital bone. The palate processes of the superior maxillary and palate bones constitute the hard palate, which is raised above the level of the rest of the base, and is surrounded by the alveolar processes containing the teeth of the upper jaw. At the anterior extremity of the hard palate, and directly behind the front incisor teeth, is the *anterior palatine* or *incisive foramen*, the termination of the anterior palatine canal, which transmits the naso-palatine nerves and anterior palatine arteries. At the posterior angles of the palate are the *posterior palatine foramina*, for the palatine nerves and arteries. Passing inwards from these foramina is the *transverse ridge*, to which are attached the aponeurotic expansions of the tensor palati muscles; and at the middle line of the posterior border, the *palate spine*, which gives origin to the azygos uvulæ. The hard palate is marked by a crucial suture, which distinguishes the four processes of which it is composed. Behind, and above the hard palate, are

the *posterior nares*, separated by the vomer, and bounded at each side by the pterygoid processes. At the base of the pterygoid processes are the *pterygo-palatine canals.* The internal pterygoid plate is long and narrow, terminated at its apex by the hamular process, and at its base by the scaphoid fossa. The external plate is broad; the space between the two is the pterygoid fossa; it contains part of the internal pterygoid muscle, and the tensor palati. Externally to the external pterygoid plate is the zygomatic fossa. Behind the nasal fossæ, in the middle line, is the under surface of the body of the sphenoid, and the basilar process of the occipital bone, and still farther back, the foramen magnum. At the base of the external

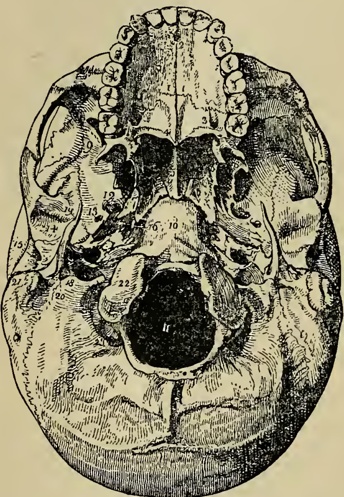


Fig. 104.—External or basilar surface of the base of the skull. 1, 1. The hard palate. The figures are placed on the palate processes of the superior maxillary bones. 2. Incisive, or anterior palatine foramen. 3. Palate process of the palate bone. The large opening near the figure is the posterior palatine foramen. 4. Palate spine; the curved line upon which the number rests is the transverse ridge. 5. Vomer, dividing the openings of the posterior nares. 6. Internal pterygoid plate. 7. Scaphoid fossa. 8. External pterygoid plate. The interval between 6 and 8 (right side of the figure) is the pterygoid fossa. 9. Zygomatic fossa. 10. Basilar process of the occipital bone. 11. Foramen magnum. 12. Foramen ovale. 13. Foramen spinosum. 14. Glenoid fossa. 15. Meatus auditorius externus. 16. Foramen lacerum basis cranii. 17. The carotid foramen of the left side. 18. Foramen lacerum posterius, or jugular foramen. 19. Styloid process. 20. Stylo-mastoid foramen. The elevation just to the right of the number is the jugular tubercle; and the groove to its left the digastric fossa. 21. Mastoid process. 22. One of the condyles of the occipital bone. 23. Posterior condylar fossa.

pterygoid plate, on each side, is the *foramen ovale*, and behind this the *foramen spinosum* with the prominent spine which gives attachment to the long internal lateral ligament of the lower jaw and laxator tympani muscle. Running outwards from the apex of the spinous process of the sphenoid bone is the fissure of Glaser, which crosses the glenoid fossa transversely, and divides it into an anterior smooth surface, bounded by the eminentia articularis, for the condyle of the lower jaw, and a posterior rough surface for a part of the parotid gland. Behind the foramen ovale and spinosum is the irregular fissure between the spinous process of the sphenoid bone and the petrous portion of the temporal, the foramen lacerum basis cranii (called also foramen lacerum medium), which lodges the internal

carotid artery and Eustachian tube, and in which the carotid branch of the Vidian nerve joins the carotid plexus. Following the direction of this fissure outwards, we see the foramen for the Eustachian tube, and that for the tensor tympani muscle, separated from each other by the processus cochleariformis. Behind the fissure is the pointed process of the petrous bone which gives origin to the levator palati muscle, and, externally to this process, the carotid foramen for the transmission of the internal carotid artery and ascending branch of the superior cervical ganglion of the sympathetic; and behind the carotid foramen, the jugular foramen and jugular fossa. Externally, and somewhat in front of the latter, is the styloid process, and at its base the vaginal process. Behind and at the foot of the styloid process is the stylo-mastoid foramen, for the facial nerve and stylo-mastoid artery, and farther outwards the mastoid process. At the inner side of the root of the mastoid process is the digastric fossa; and a little farther inwards, the occipital groove. On the sides of the foramen magnum, and near its anterior circumference, are the condyles of the occipital bone. In front of each condyle, and piercing its base, is the anterior condylar foramen for the hypoglossal nerve, and directly behind the condyle the irregular fossa in which the posterior condylar foramen is situated. Behind the foramen magnum are the two curved lines of the occipital bone, the spine, and the protuberance, with the rough surfaces for the attachment of muscles.

The **Face** is somewhat oval in contour, uneven in surface, and excavated for the reception of two principal organs of sense, the eye and the nose. It is formed by part of the frontal bone, and by the bones of the face. Superiorly it is bounded by the frontal eminences; beneath these are the superciliary ridges, converging towards the nasal tuberosity; beneath the superciliary ridges are the supraorbital ridges, terminating externally in the external border of the orbit, and internally in the internal border, and presenting towards their inner third the supraorbital notch, for the supraorbital nerve and artery. Beneath the supraorbital ridges are the cavities of the orbits. Between the orbits is the bridge of the nose, overarching the anterior nares; and on each side of the nares the canine fossa of the superior maxillary bone, the infraorbital foramen, and still farther outwards the prominence of the malar bone; at the lower margin of the nares is the nasal spine, and beneath it the superior alveolar arch, containing the teeth of the upper jaw. Forming the lower boundary of the face is the lower jaw, containing in its alveolar process the lower teeth, and projecting inferiorly to constitute the chin; on either side of the chin is the mental foramen. If a perpendicular line be drawn from the inner third of the supraorbital ridge to the inner third of the body of the lower jaw, it will be found to intersect three openings: the supraorbital, infraorbital, and mental, each giving passage to a facial branch of the fifth nerve.

ORBITS.

The *orbits* are two quadrilateral hollow cones, situated in the upper part of the face, and intended for the reception of the eye-balls, with their muscles, vessels, and nerves, and the lachrymal glands. The central axis of each orbit is directed outwards, so that the axes of the two, continued into the skull through the optic foramina, would intersect over the middle of the sella turcica. The *superior boundary* of the orbit is formed by the orbital plate of the frontal bone, and part of the lesser wing of the sphenoid ; the *inferior* by part of the malar bone, superior maxillary, and palate bone ; the *internal*, by the lachrymal bone, os planum of the ethmoid, and part of the body of the sphenoid ; the *external*, by the orbital process of the malar bone and great wing of the sphenoid. These may be expressed more clearly in a tabular form :—

	Frontal. Sphenoid (lesser wing).	
Outer wall. Malar. Sphenoid (greater wing).	Orbit.	*Inner wall.* Lachrymal. Ethmoid (os planum). Sphenoid (body).
	Malar. Superior Maxillary. Palate.	

There are *nine* openings communicating with the orbit : the *optic*, for the admission of the optic nerve and ophthalmic artery ; the *sphenoidal fissure*, for the transmission of the third, fourth, the three branches of the ophthalmic division of the fifth nerve, the sixth nerve, and the ophthalmic vein ; the *spheno-maxillary fissure*, for the passage of the superior maxillary nerve and infraorbital artery to the opening of entrance of the *infraorbital canal ; temporo-malar foramina*, two or three small openings in the orbital process of the malar bone, for the passage of filaments of the orbital branch of the superior maxillary nerve ; *anterior* and *posterior ethmoidal foramina* in the suture between the os planum and frontal bone, the former transmitting the nasal nerve and anterior ethmoidal artery, the latter the posterior ethmoidal artery and vein ; the opening of the *nasal duct ;* and the *supraorbital notch* or foramen, for the supra-orbital nerve and artery.

SPHENO-MAXILLARY FOSSA.

This is a small space situated between the bones of the head and those of the face ; it corresponds in position to the junction of the spheno-maxillary and pterygo-maxillary fissures. It is triangular in

form, and is bounded above by the body of the sphenoid, in front by the superior maxillary, behind by the base of the pterygoid plate of the sphenoid, internally by the vertical plate of the palate; it is wide above, near the base of the skull, but narrow below, where it is continued into the upper part of the descending palatine canal. The fossa has opening into it three fissures and five foramina: the former are the sphenoidal, spheno-maxillary, and pterygo-maxillary; the latter are the foramen rotundum, Vidian, descending palatine, pterygo-palatine, and spheno-palatine. The foramen rotundum, Vidian, and pterygo-palatine foramina are on the posterior wall, being placed in the order of their enumeration from above downwards; the spheno-palatine is on the inner wall, and the descending palatine below. The fossa lodges Meckel's ganglia and the third part of the internal maxillary artery; and the foramina which open into it (with the exception of the foramen rotundum) give passage to nerve-twigs derived from the ganglion and small branches of the artery.

NASAL FOSSÆ.

The nasal fossæ are two irregular cavities, situated in the middle of the face, and extending from before backwards. They are bounded *above* by the nasal bones, ethmoid, and sphenoid; *below* by the palate processes of the superior maxillary and palate bones; *externally* by the superior maxillary, lachrymal, inferior turbinated, superior and middle turbinated bones of the ethmoid, palate, and internal pterygoid plate of the sphenoid; and the two fossæ are separated by the vomer and perpendicular lamella of the ethmoid. These may be more clearly expressed in a tabular form:—

		Nasal bones. Ethmoid. Sphenoid.		
Superior maxillary. Lachrymal. Inferior turbinated. Ethmoid. Palate. Internal pterygoid plate.	Nasal fossa.	Vomer and ethmoidal plate.	Nasal fossa.	Superior maxillary. Lachrymal. Inferior turbinated. Ethmoid. Palate. Internal pterygoid plate.
		Palate processes of superior maxillary. Palate processes of palate bone.		

Each nasal fossa is divided into three irregular longitudinal passages, or *meatuses*, by three processes of bone, which project from its

outer wall—the superior, middle, and inferior turbinated bone; the superior and middle turbinated bone being processes of the ethmoid; the inferior, a distinct bone of the face. The **superior meatus** occupies the superior and posterior part of each fossa: it is situated between the superior and middle turbinated bone, and has opening into it three foramina—viz., foramen of the posterior ethmoid cells, foramen of the sphenoid cells, and spheno-palatine foramen. The **middle meatus** is the space between the middle and inferior turbinated bone; it also presents three foramina, the opening of the

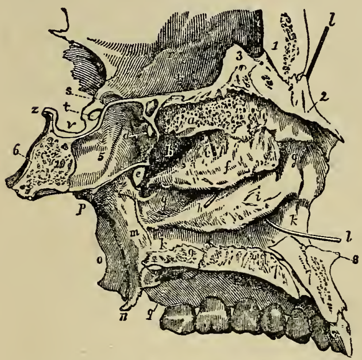


FIG. 105.—Longitudinal section of the nasal fossæ made immediately to the right of the middle line, the bony septum removed in order to show the external wall of the left fossa. 1. Frontal bone. 2. Nasal bone. 3. Crista galli. The groove between 1 and 3 is the lateral boundary of the foramen cæcum. 4. Cribriform plate of the ethmoid. 5. Sphenoidal cells. Bones 2, 4, and 5 form the superior boundary of the nasal fossa. 6. Basilar portion of the sphenoid bone. 7, 7. Palate process of superior maxillary bone. The groove between 7, 7, is the lateral half of the incisive canal, and the dark aperture in the groove the inferior termination of the left naso-palatine canal. 8. Nasal spine. 9. Palate process of palate bone. *a.* Superior turbinated bone. *b.* Superior meatus. *c.* A probe passed into the posterior ethmoidal cells. *d.* Opening of the sphenoidal cells into the superior meatus. *e.* Spheno-palatine foramen. *f.* Middle turbinated bone. *g, g.* Middle meatus. *h.* A probe passed into the infundibular canal leading from the frontal sinuses and anterior ethmoidal cells; the triangular aperture immediately above the letter is the opening of the antrum. *i.* Inferior turbinated bone. *k, k.* Inferior meatus. *l, l.* A probe passed up the nasal duct, showing the direction of that canal. *m.* Internal pterygoid plate. *n.* Its hamular process. *o.* External pterygoid plate. *p.* Root of pterygoid processes. *q.* Posterior palatine foramina. *r.* Roof of the left orbit. *s.* Optic foramen. *t.* Groove for the last turn of the internal carotid artery converted into a foramen by the development of an osseous communication between the anterior and middle clinoid process. *v.* Sella turcica. *z.* Posterior clinoid process.

frontal sinus, of the anterior ethmoid cells, and of the antrum. The largest of the three passages is the **inferior meatus**, which is the space between the inferior turbinated bone and the floor of the nasal fossa; in it there are two foramina, the termination of the nasal duct, and the opening of the anterior palatine canal. In the recent state the Eustachian tube looks forward into the nares, and opens into the pharynx just behind the inferior meatus; it may therefore be considered practically as a third opening into the latter. The nasal fossæ commence upon the face by a large irregular opening, the anterior nares, and terminate posteriorly in the two posterior nares.

VERTEBRAL THEORY OF THE SKULL.

According to this theory, the skull consists of a series of vertebræ, modified to suit its primary idea, that of protecting the brain and lodging the organs of sensation. The base of the skull from the front of the foramen magnum to the crista galli constitutes the centra; the expanded cranial bones form the neural arches; and the hyoid bone and bones of the face are the hæmal arches. It is usually considered to be composed of four vertebræ.

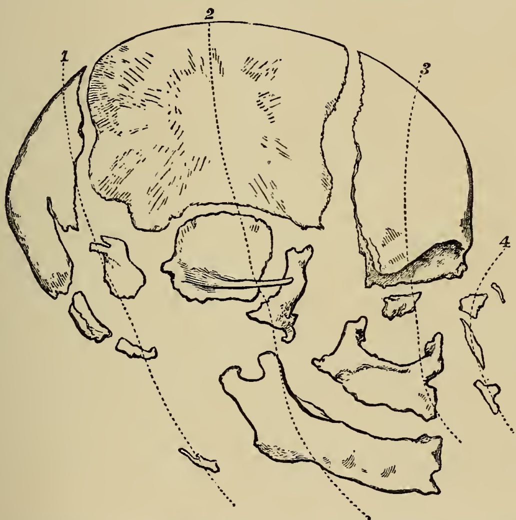


FIG. 106.—The four cranial vertebræ; the dotted lines pass through the elements of each. 1. The occipital. 2. The parietal or post-sphenoid. 3. The frontal or pre-sphenoid. 4. The nasal or ethmoid.

The **occipital** vertebra is composed as follows:—The basilar process is the *centrum*, the foramen magnum the *neural canal*, the cranial flattened part of the occipital the *neural spine*. The *hœmal arch* is composed of the styloid process of the mastoid bone, which is considered to belong to the occipital rather than the temporal; and the stylo-hyoid ligament, which is the homologue of the osseous part of the hyoidean arch in many animals, and is rudimentary in man. The *hœmal spine* is the body of the hyoid bone.

The **parietal** or **post-sphenoid** vertebra has for *centrum* the body of the sphenoid as far forward as the olivary process, which latter part, along with the sphenoidal spongy bones, is developed separately. The posterior division of the body is called the *post-sphenoid* bone. The *neural arch* is formed of the greater wings and the parietal

bones; the squamous bones being additions. The *hæmal arch* is the lower jaw.

The **frontal** or **pre-sphenoid** vertebra has for its centrum the anterior division of the sphenoid called the *pre-sphenoid.* The *neural arch* is constituted by the lesser wings and the frontal bone. The *hæmal arch* is more difficult to recognise, but is formed of the palate and superior maxillary bones.

The **ethmoid** or **nasal** vertebra.—This segment departs so far from the typical vertebra that its parts are with difficulty recognisable. Its *centrum* is the perpendicular lamella of the ethmoid bone prolonged up into the crista galli. The cribriform plates and nasal bones are considered to form the *neural arch.* The only part of the *hæmal arch* which can be recognised is the *hæmal spine* formed by the inter-maxillary or incisive part of the superior maxillary. This is supported on the extremity of the vomer, a continuation downwards of the centrum, and nothing corresponding to the lateral parts of the *hæmal arch* or *hæmapophyses* can be observed.

Certain parts of the bones of the head are excluded from the above enumeration, such as the petrous, the tympanic, the pterygoid, the malar, the lachrymal; these are considered to be either *sense capsules,* or diverging appendages and parts of transverse processes.

It must be stated that there is room for considerable difference of opinion as to the particular segment to which some portions of the partially developed skull ought to be assigned, and in the completed skull all trace of segmentation in the base has disappeared. The observations of Huxley and Parker on the development of the vertebrate skeleton, seem to throw doubt on the segmentation of the cranial base in its earliest stage, and indeed on the whole theory which recognises in the skull the coalescence of modified vertebræ. It is sufficient for a text-book that the general principle of the differentiation should be indicated, leaving the student who is interested in the matter to study it in works devoted to the subject.

TEETH.

Man is provided with two sets of teeth, which appear the one in succession to the other; the first are the teeth of childhood—they are called temporary, deciduous, or milk-teeth; the second continue until old age, and are named permanent.

The **permanent teeth** are thirty-two in number, sixteen in each jaw; they are divisible into four classes: *incisors,* of which there are four in each jaw, two central and two lateral; *canine,* two above and two below; *bicuspid,* four above and four below; and *molars,* six above and six below.

The **temporary teeth** are twenty in number: eight incisors, four canines, and eight molars. There are no bicuspids in the temporary set, but the eight deciduous molars are succeeded by the permanent bicuspids.

The following table shows the position of the teeth relative to each other, in each set, and the relation of those of the temporary to those of the permanent series :—

		Mo.	Ca.	In.	Ca.	Mo.		
Temporary teeth.	Upper	2	1	4	1	2	=10	=20
	Lower	2	1	4	1	2	=10	

		Mo.	Bi.	Ca.	In.	Ca.	Bi.	Mo.		
Permanent teeth.	Upper	3	2	1	4	1	2	3	=16	=32
	Lower	3	2	1	4	1	2	3	=16	

Every tooth is divisible into a *crown*, which is the part above the gum ; a constricted portion around the base of the crown, the *neck ;* and a *root* or *fang*, which is contained within the alveolus. The root is invested by periosteum, which is a bond of connection between it and the alveolus.

Characters of the Permanent Teeth.—The **incisors** (cutting teeth) are named from presenting a sharp and cutting edge, formed at the expense of the posterior surface. The crown is flattened from before backwards, being somewhat convex in front and concave behind ; the neck is much constricted, and the root compressed from side to side ; at its apex is a small opening for the passage of the nerve and artery of the tooth. The upper incisors are directed a little forwards ; they are larger than the lower, and slightly overlap them. The upper central incisors are much larger than the laterals ; their inner border is a little longer than their outer, and by this character we can distinguish the side to which a particular specimen belongs. In the lower jaw the central incisors are smaller than the lateral, and have their fangs much flattened from side to side. The fangs of the lateral incisors are also flattened, but are longer than those of the central teeth.

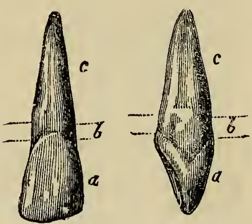


Fig. 107.—Front and side view of a left upper central incisor. *a.* Distal surface. *b.* Neck. *c.* root.

The **canine** teeth (cuspidati) follow the incisors in order from before backwards ; two are situated in the upper jaw, one at each side, and two in the lower. The crown is larger than that of the incisors, convex before, concave behind, and tapering to a blunted point or cusp. The root is longer than that of all the other teeth, compressed at each side, and marked by a slight groove. The upper canine teeth (called eye-teeth) are longer and larger than the lower, and are situated a little behind and external to them.

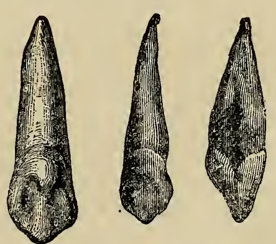


Fig. 108.—Lingual, labial, and distal surfaces of an upper canine.

The **bicuspid** teeth (bicuspidati, premolars), two at each side in each jaw, follow the canine, and are intermediate in size between them and the molars. The crown is compressed from before backwards, and surmounted by two tubercles, one internal, the other external, the latter being the largest. The neck is oval; the root is compressed, marked on each side by a deep groove, and bifid near its apex. The teeth of the upper jaw have a greater tendency to the division of their roots than those of the lower, and the posterior than the anterior pair. The lower bicuspids are smaller than the upper; their outer cusp is long and prominent, and is bent inwards; the inner cusp is smaller, and is connected with the outer by a slight ridge.

FIG. 109.—Grinding surface of an upper bicuspid.

The **molar** teeth (multicuspidati, grinders), three at each side in each jaw, are the largest of the permanent set. The first molar is the largest and broadest, and the third is the smallest, so that there is a gradation of size of these teeth. The crown is quadrilateral, and is surmounted by four or five tubercles (four in the upper, five in the lower molars); the neck is large and round, and the root divided into several fangs. In the upper jaw the first and second molar teeth have three roots, sometimes four, more or less widely separated from each other, two of the roots being external, the other

FIG. 110.—Masticating surface of a first upper molar of the left side.

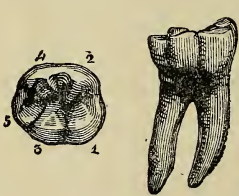


FIG. 111.—Masticating surface and side view of first lower molar of right side. The small figures indicate the five cusps.

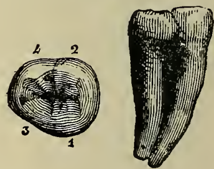


FIG. 112.—Masticating surface and side view of second lower molar of right side. The small figures indicate the four cusps.

internal. In the lower there are but two roots, anterior and posterior, flattened from behind forwards, and grooved so as to mark a tendency to division. The third molars, or *wisdom-teeth* (dentes sapientiæ), are smaller than the other two; they present three tubercles on the surface of the crown, and the root is single and grooved, appearing to be made up of four or five fangs compressed together, or partially divided. In the lower jaw the fangs are frequently separated to some distance from each other, and curved backwards, so as to offer considerable resistance in the operation of extraction.

The range of teeth in each jaw forms a pretty uniform curve, without any break or *diastema*, such as occurs to some extent in the Quadrumana, and more markedly in the Rodents and Ruminants.

Characters of the Temporary Teeth.—In general form these resemble the teeth of the permanent set, but they are smaller. The enamel which covers the crown terminates in a more distinct edge than in the permanent teeth, so that the neck is more evidently constricted. The canines are relatively shorter, and their crowns broader than those which succeed them. The second molar is the largest, being indeed larger than the second permanent bicuspid which succeeds it. The first upper molar has only three cusps, the second has four, the first lower molar has four and the second five cusps. The fangs are like those of the permanent set, but are smaller and more divergent.

STRUCTURE OF THE TEETH.

If a vertical section be made through a tooth, it will be found to be hollowed out in its interior into a small cavity, the *pulp cavity,* which has a general resemblance in its form to the external configuration of the tooth. It extends upwards a little into the cusps, and is prolonged downwards into the fangs, terminating at the extremity of each of the latter in a small opening which transmits the vessels and nerves. This cavity is filled with a soft, highly vascular, and sensitive substance, called the *dental pulp,* which consists of gelatinous tissue intermingled with nucleated cells, and supports capillary loops and minute nerve fibres; the pulp is continuous through the apertures at the extremity of the fangs with the periosteum on the outside of the tooth.

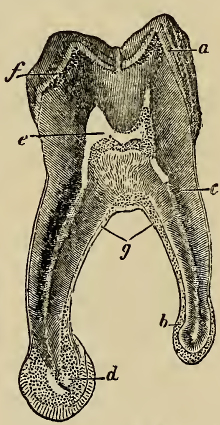


FIG. 113.—Vertical section of molar tooth. *a.* Enamel. *b, g.* Cementum. *c.* Dentine. *d.* Osseous excrescence at end of fang. *e.* Pulp cavity. *f.* Lacunar spaces at outer part of dentine.

The solid portion of the tooth is composed of three distinct structures:—(1) The **dentine** or **ivory**, which forms the bulk of the tooth; (2) the **enamel**, which forms a thick covering to the crown; and (3) the **cement**, which covers the fang externally.

The **dentine** (ivory or tooth bone) is a hard substance having some resemblance to bone, but on microscopic examination it appears to consist of very minute, tapering, and branching tubules, embedded in a dense, homogeneous intertubular matrix. These tubules commence by their larger ends in the wall of the pulp cavity, and pursue a radiating and serpentine course towards the periphery of the tooth; they give off minute branches from their sides, and divide dichotomously as they proceed, so that when they reach the outer

layers of the dentine they have become very numerous and minute. Upon cross section the dentinal tubules appear each to be surrounded

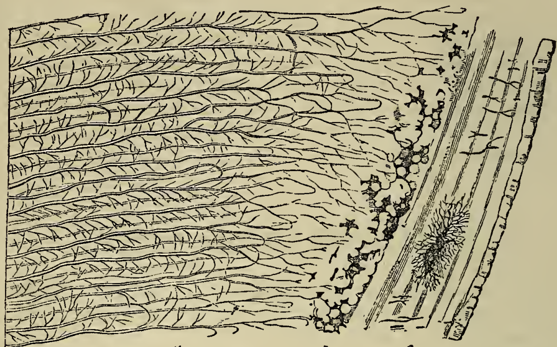


Fig. 114.—Section of dentine in the direction of the tubules. *a*. Dentinal tubules. *b*. Nodular layer. *c*. Cement.

by an annulus of considerable thickness (fig. 115); but it is probable that this appearance results from the obliquity of the section, by which a certain length of the tubes is seen as well as their extremities. The true wall of the canal can only be seen as a faint yellow ring (dentinal sheath of Neumann), and even this is not always manifest. In the recent state the tubules are occupied by a protoplasmic substance (dentinal fibre of Tomes), which is continuous with the nucleated cells of the dental pulp, and which serves to convey nutritive material to the dentine; it appears also to confer on the latter a certain amount of sensibility. The tubules are most numerous in the crown (fig. 115, A), where they are closely crowded together, while in the fang they are much more scattered, so that here the matrix forms the largest element (fig. 115, B). The matrix of the dentine appears to be perfectly homogeneous, without trace of fibres or granules; when softened by reagents it has a tendency to split up into laminæ, but no such lamination is observable in hard sections. The surface of the dentine which is in contact with the enamel is marked by hexagonal depressions, corresponding to the ends of the enamel fibres. In the fang the outer portion

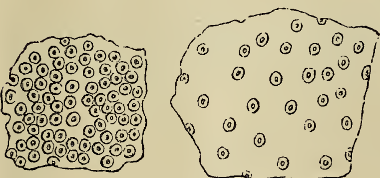


Fig. 115.—Transverse section of dentine, showing the tubules cut across. A, in the crown; B, in the fang.

of the dentine—namely, that next the cement—has often a peculiar nodular appearance (fig. 114, *b*), which results from the incomplete fusion of the calcareous masses when they are deposited. Frequently also we find in this situation irregular lacunar spaces, which are filled with the same protoplasmic material as the dentinal tubules.

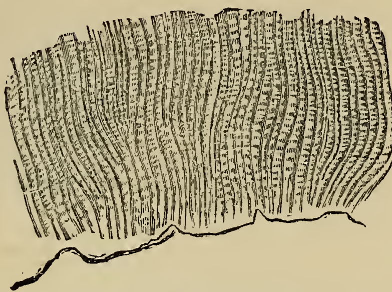


FIG. 116.—Longitudinal section of the enamel, showing the wavy arrangement of the fibres, and the faint transverse striations.

The **enamel** forms a crust over the whole exposed surface of the crown of the tooth to the commencement of its root; it is thickest on the summit of the tooth, and becomes gradually thinner as it approaches the neck. It is translucent and bluish in thin sections, and is the hardest and most brittle substance in the body; it contains only about $3\frac{1}{2}$ per cent. of animal matter.

The enamel is composed of minute fibres which run in a wavy course from the dentine to the free surface of the crown, and which on cross section are seen to be hexagonal (fig. 117, A). By their attached ends they fit into the pits already described as existing on the surface of the dentine. The enamel fibres are marked at irregular intervals by transverse lines (fig. 117, B), which possibly may indicate their formation from aggregated cells, although this is denied by many histologists, who consider them to result from the fibres of superimposed layers running in opposite directions. The enamel is covered by a thin membrane (composed of non-nucleated horny scales) which separates from it on the application of hydrochloric acid—this is called the *cuticle of the enamel*, or *Nasmyth's membrane*.

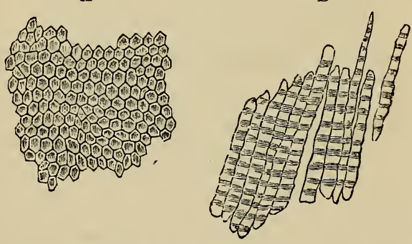


FIG. 117.—A. Transverse section of the enamel, showing the fibres to be irregularly hexagonal. B. Detached enamel fibres, more highly magnified than in fig. 116.

The cortical substance, or **cement**, forms a thin coating over the root of the tooth, from the termination of the enamel to the opening in the apex of the fang. In structure it is analogous to bone, and is characterised by the presence of lacunæ and canaliculi (fig. 114, *c*), but it generally has no Haversian canals, although these also may

appear in the cement in old age. It increases in thickness as age advances, and gives rise to those exostosed appearances occasionally seen on the teeth of very old persons, or in those who have taken much mercury. In old age the pulp cavity is often filled up and obliterated by osseous substance analogous to the cement, but bearing also some resemblance to dentine. This is called *osteodentine;* it is traversed by canals which are surrounded by concentric laminæ, like the Haversian canals of bone.

The **tooth pulp**, as stated above, is continuous with the periosteum of the alveolus. On its surface is a layer of fine columnar cells which are in close contact externally with the inner surface of the dentine, and contain oval nuclei at their bases; as they are chiefly instrumental in the formation of that tissue, they have received the name of "odontoblasts." Some authors state that they give off processes which pass into the dentinal tubules and become continuous with the fibres therein contained. Beneath these, numerous fusiform or pyramidal cells are found, many of which wedge themselves in between the odontoblasts, while others are continuous with the ramified cells of the reticulum to be presently mentioned. Klein believes that it is this deeper cell stratum and not the layer of odontoblasts which sends processes into the dentinal tubules. The cells of the pulp, as well as the blood-vessels and nerves, are supported by a fine reticulum formed by ramified nucleated cells. Numerous non-medullated nerve fibres run through the pulp, some of which have been traced to the layer of odontoblasts, and it is probable that they also pass into the dentine. A dense network of capillaries occupies the outer part of the pulp.

DEVELOPMENT OF THE TEETH.

At the time when the germs of the teeth first make their appearance the lower jaw consists of embryonic tissue, composed chiefly of branched cells, in which a cartilaginous rod, the *cartilage of Meckel*, is embedded. At this period the superior maxillary processes, formed also of embryonic tissue, have just met and united with the pre-maxillary or inter-maxillary process. In the position of the future alveolar border an upgrowth of epithelial cells produces two narrow ridges arranged in a horse-shoe form; the groove between these ridges (formerly described as the *primitive dental groove*) is almost entirely filled up with cells which are actively growing and rapidly increasing in number. This growth of cells takes a downward as well as an upward course so as to invade the tissue occupying the position of the future jaw, but instead of passing vertically downwards becomes inclined inwards at its lower extremity (see fig. 118, 1); in cross section this inflection of cells closely resembles a tubular gland. At their deepest point the cells increase in number more rapidly than elsewhere so as to result in the production of expansions taking somewhat the form of Florence flasks; and it is

noticeable that while the inflection of cells takes place along the whole circumference of the jaw, the expansions are only produced at those points where teeth are to be developed. The cells of the surface of the enlargements are columnar, those of the interior are polygonal or stellate. By a more rapid downward growth at the sides than in the centre, these processes assume a cupped or bell shape with the concavity directed downwards, and into this concavity the dentinal papilla is received. The expansions have long received the name of *enamel germs*, or *enamel organs*, although much difference of opinion exists as to the part played by them in the production of enamel. The outer cells of the enamel organ either remain unchanged or become slightly atrophied; those which lie on its cupped or concave surface become greatly elongated, and their nuclei recede to their bases; the central cells become chiefly converted into a stellate reticulum, the processes of the cells communicating freely with each other, but those which lie in contact with the columnar cells next the dentinal papilla remain unchanged and form a *stratum intermedium*. During these changes, and for long after, the epithelium constituting the enamel organ remains connected with that on the surface of the jaw by a narrow process or neck.

FIG. 118.—Three stages in the development of a mammalian tooth germ. *a.* Oral epithelium heaped up over germ. *b.* Younger epithelial cells. *c.* Deep layer of cells. *d.* Inflection of epithelium for enamel germ. *e.* Stellate reticulum. *f.* Dentine germ. *g.* Inner portion of future tooth sac. *h.* Outer portion of future tooth sac. *i.* Vessels cut across. *k.* Bone of jaw.

The *dentinal papillæ* are first observed as slightly opaque spots at

some little distance from the surface and at points corresponding to the flask-like expansions above described ; they are almost as early in making their appearance as the latter, but are at first much slower in development, so that the enamel organ is for some time very large in proportion to the dentinal papilla. Not only does the dentinal papilla grow upwards into the cupped cavity formed by the lower part of the enamel germ, but it also gives off lateral processes which pass to the sides of that organ, and by a continuous upward growth come later to enclose it and form the dental sac. At first the dentinal papilla only differs from the rest of the substance of the jaw in being more vascular and containing more cells, but it soon assumes the form of the future tooth, becoming simply conical for a canine, having two cusps for a bicuspid, and four or five for a molar. The cells on the surface of it become distinguished from the rest by their columnar form and close aggregation, so that they form a compact layer, which, from the part it plays in the formation of the dentine, has been named the *membrana eboris*, the individual cells being called *odontoblasts*. These cells are furnished with processes by means of which they communicate with each other, or with the cells deeper in the pulp ; some of the processes also pass into the dentine when it is formed, and become continuous with the protoplasm contained in the dentinal tubules.

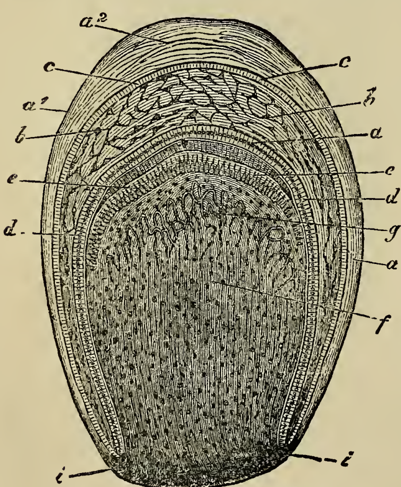


Fig 119.—Dental sac of a tolerably mature human fœtus, partly diagrammatic. a^1. Outer layer, and a^2 deeper layer of fibrous wall of sac. *b*, *b*. Stellate reticulum of enamel organ. *c*, *c*. Outer cells, and *d*, *d*, inner cells of enamel organ. *f*. Dental papilla with its capillaries, *g*. *i*, *i*. Continuation of connective tissue of the parieties of the sac into the dental papilla.

The enamel germ for the permanent tooth is produced by an outgrowth of epithelial cells from the side of the neck of the enamel organ of the temporary tooth ; this passes to the back and inner side of the latter, and undergoes the same changes in shape and composition as have been described above to take place in the germ of the temporary tooth. The dentinal papilla also of the permanent tooth grows up beneath its enamel germ, and, assuming the characteristic shape of the tooth to be formed, has its superficial cells elongated and aggregated so as to form a membrana eboris, exactly in the same way as

we have traced it in the case of the temporary tooth. The germ of the first permanent molar is formed about the sixteenth week by a down-growth of the epithelium from the surface of the jaw, in the same way as the germ for the temporary teeth originated; the second permanent molar has its germ formed from the neck of the enamel organ of the first molar about the third month after birth. The germ for the wisdom tooth is formed from the neck of the enamel germ of the second permanent molar about the third year.

FORMATION OF THE HARD TISSUES.

Enamel.—We have seen that the deeper cells of the enamel organ (those, namely, which are next to the dentinal papilla) become elongated; they also, by their mutual pressure, come to assume the form of elongated hexagonal prisms, and receive the distinctive title of *enamel cells*. A deposition of calcareous salts takes place in these cells, commencing at the end nearest to the papilla, and proceeding towards the centre of the enamel organ. As the process advances, the cells of the stratum intermedium assume the same form as the deeper cells, and in process of time become also calcified; the stellate reticulum which forms the great part of the enamel organ seems to take no active part in the formation of the enamel, but, as the latter is formed, becomes progressively reduced in quantity until at length the outer or superficial cells (still epithelial in character, and become flattened) are in contact with the enamel cells. As the latter are hexagonal in form (from mutual compression), the fibres which result from their calcification are necessarily hexagonal prisms. The outer part of the cell is first calcified, the centre later, so that the outer part of the prismatic fibre is the hardest; and when fracture of the enamel takes place it usually follows the line of the centre of the fibre, this being less perfectly calcified than the periphery.

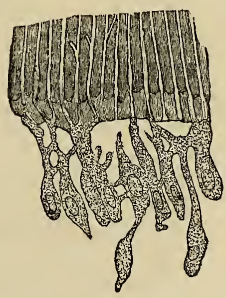


FIG. 120.—Odontoblasts *in situ*.

Dentine.—The cells which form a compact layer on the surface of the dentinal papilla and are called odontoblasts, become calcified in the same manner as the enamel cells. The calcareous deposit takes place first at the surface nearest to the enamel and passes inwards along the elongated cell; while the outer part of the cell is thus converted into dentine, the inner end continues to grow towards the papilla, and thus each dentinal tubule and its surrounding matrix is formed by the calcification of a single cell, and not, as was formerly supposed, by the union of several. Most observers agree in stating that the dentinal matrix, dentinal sheaths, and the fibres contained in the tubules, represent three stages of calcification, the matrix exhibiting the completion of the process, the sheaths of Neumann an imperfect calcification, and the fibres being the

unchanged protoplasm of the original cell. Klein is, however, of opinion that the fibres contained in the tubules are derived from the processes of the deeper layers of cells, and are not the product of the odontoblasts. The part of the dentinal papilla which is not converted into dentine, remains throughout life as the pulp of the tooth.

Cement.—This is produced by the tissue of the tooth sac, the process being precisely the same as the production of bone beneath periosteum, described on a previous page.

ERUPTION OF TEETH.

When the crown of the tooth has been formed and coated with enamel, and the fang has grown to the bottom of its socket by the progressive lengthening of the pulp, the formation of the dentine, and the adhesion of the latter to the contiguous portion of the sac, the pressure of the socket causes the reflected part of the sac and the edge of the tooth to approach, and the latter to pass through the gum.

The opened sac now begins to shorten more rapidly than the fang lengthens, and the tooth is quickly drawn upwards by the contraction, leaving a space between the extremity of the unfinished root and the bottom of the socket, in which the growth and completion of the fang are effected.

During the changes above described as taking place among the dental sacs contained within the jaws, the septa between the sacs, at first consisting of spongy tissue, gradually become fibrous, and subsequently osseous, the bone being developed from the surface and proceeding by degrees more deeply into the jaws to constitute the alveoli. The necks of the sacs of the permanent teeth, by which they originally communicated with the mucous surface of the gum, still exist, in the form of cords, separated from the deciduous teeth by their alveolus, but communicating through minute osseous canals with the mucous membrane of the mouth immediately behind the corresponding deciduous teeth.

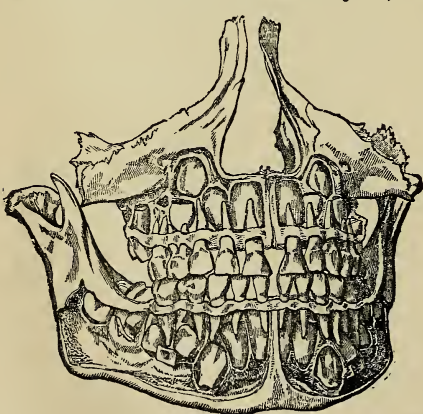


Fig. 121.—Normal well-formed jaws from which the alveolar plate has been removed, so as to expose the developing permanent teeth in their crypts in the jaws.

The periods of appearance of the teeth are very irregular; it is necessary, therefore, to have recourse to an average, which may be stated in a tabular form as follows, the teeth of the lower jaw preceding those of the upper by a short interval.

SUCCESSION OF TEETH.

1. *Temporary Teeth.*

	Molar 2	Molar 1	Canine	Incisors	Canine	Molar 1	Molar 2
Months.	24	12	18	9.7.7.9	18	12	24

2. *Permanent Teeth.*

	Molar 3	Molar 2	Molar 1	Canine	Incisors	Canine	Molar 1	Molar 2	Molar 3
Years.	17–21	12–13	6	11–12	8.7.7.8	11–12	6	12–13	17–21

OS HYOIDES.

The os hyoides gives support to the tongue, and attachment to numerous muscles in the neck. It is named from its resemblance to the Greek letter υ, and consists of a central portion or body, of two larger cornua, which project backwards from the body; and two lesser cornua, which ascend from the angle of union between the body and the greater cornua.

The body is somewhat quadrilateral, rough and convex on its antero-superior surface, by which it gives attachment to muscles; concave and smooth on the postero-inferior surface, by which it lies in contact with the thyro-hyoidean membrane. The greater cornua are flattened from above downwards, and terminated posteriorly by a tubercle; and the lesser cornua, conical in form, give attachment to the stylo-hyoid ligaments. In early age and in the adult the cornua are connected with the body by cartilaginous surfaces and ligamentous fibres; in old age they become united by bone.

Fig. 122.—The os hyoides seen from before. 1. Antero-superior, or convex side of the body. 2. Great cornua of the left side. 3. Lesser cornua of the same side.

Development.—By *five* centres, one for the body, and one for each cornu. Ossification commences in the greater cornua and body during the last month of fœtal life, and in the lesser cornua soon

after birth. The cornua do not unite with the body till after middle life.

Attachment of Muscles.—To *eleven* pairs: sterno-hyoid, thyro-hyoid, omo-hyoid, pulley of the digastricus, stylo-hyoid, mylo-hyoid, genio-hyoid, genio-hyo-glossus, hyo-glossus, lingualis, and middle constrictor of the pharynx. It also gives attachment to the stylo-hyoid, thyro-hyoid, and hyo-epiglottic ligaments, and to the thyro-hyoidean membrane.

THORAX AND UPPER EXTREMITY.

The bones of the thorax are the sternum and ribs; and those of the upper extremity, the clavicle, scapula, humerus, ulna, and radius, bones of the carpus, metacarpus, and phalanges.

STERNUM.

The sternum (fig. 123) is situated in the middle line of the front of the chest, and is oblique in direction, the superior end lying within a few inches of the vertebral column, the inferior being projected forwards so as to be placed at a considerable distance from the spine. The bone is flat in front, and marked by five transverse lines which indicate its original subdivision into six pieces. It is slightly concave behind, broad and thick above, flattened and pointed below, and divisible in the adult into three pieces, superior, middle, and inferior, or presternum, mesosternum, and metasternum.

The **superior piece** or manubrium is nearly quadrilateral; it is broad and thick above, where it presents a concave border, supra-sternal notch; and narrow at its junction with the middle piece. At each superior angle is a deep articular depression for the clavicle; and on either side two notches for articulation with the cartilage of the first rib, and one-half that of the second. The articulation of the manubrium with the body is often movable, often anchylosed: when the latter state exists, the line of union is marked by a transverse ridge.

The **middle piece** or gladiolus, considerably longer than the superior, is broad in the middle, and somewhat narrower at each extremity. It presents at either side six articular notches for the lower half of the second rib, the four next ribs, and the upper half of the seventh. The articular notches are placed opposite to the lines which indicate the original subdivision of the bone. This piece is sometimes perforated by an opening of variable size, resulting from arrest of development.

The **inferior piece** (ensiform or xiphoid cartilage) is the smallest of the three, often merely cartilaginous, and very variable in appearance, being sometimes pointed, at other times broad and thin, and at other times, again, perforated by a round hole, or bifid. It presents a notch at each side for articulation with the lower half of the cartilage of the seventh rib.

Development.—The sternum is usually developed from *six* centres, one for each of the segments of which the bone primarily consists. Ossification commences in the manubrium towards the end of the six month of fœtal life, in the second segment about the seventh or eighth month, in the third and fourth about the time of birth, and in the fifth segment during the first year. The osseous centre for the ensiform cartilage is very variable in its advent, being first apparent at any period from the sixth to the fifteenth year, or even later. Frequently, additional nuclei appear in several of the segments, this being more especially the case with the manubrium, in which as many as six centres have occasionally been observed; in the third, fourth, and fifth segments there are frequently two centres which are placed laterally, and it is the irregular union of these pairs that gives rise to the foramina occasionally seen in the sternum towards its lower part. Union of the pieces of the sternum commences from below and proceeds upwards; the fifth piece unites with the fourth at about puberty, the fourth and third between twenty and twenty-five, the third and second between twenty-five and thirty. The ensiform appendix becomes joined to the body of the sternum at forty or fifty years; and the manubrium to the body only in very old age. Two small pisiform pieces have been described by Béclard and Breschet, as being situated upon and somewhat behind each extremity of the supra-sternal notch of the upper border of the manubrium. These supra-sternal pieces, by no means constant, appear at about the thirty-fifth year. Béclard considers them as the analogue of the fourchette of birds, and Breschet as the sternal ends of a pair of cervical ribs.

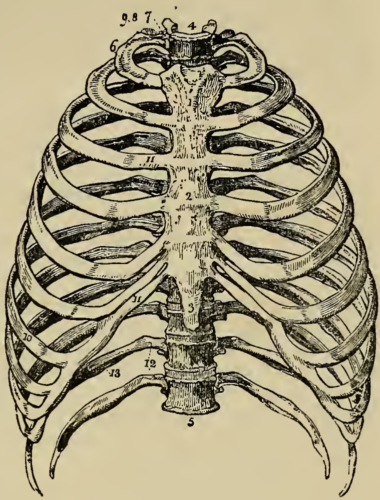


FIG. 123.—Anterior view of the thorax. 1. Superior piece of the sternum or manubrium. 2. Middle piece, or gladiolus. 3. Inferior piece, or ensiform cartilage. 4. First dorsal vertebra. 5. Last dorsal vertebra. 6. First rib. 7. Its head. 8. Its neck, resting against the transverse process of the first dorsal vertebra. 9. Its tubercle. 10. Seventh or last true rib. 11. Costal cartilages of the true ribs. 12. The last two false ribs or floating ribs. 13. The groove along the lower border of the rib.

Articulations.—With the clavicles and seven costal cartilages on each side.

Attachment of Muscles.—To *nine* pairs and one single muscle —viz., by its *anterior surface* to the pectoralis major, by its *upper border* to the sterno-mastoid, by the *upper and posterior part of the manubrium* to the sterno-hyoid and sterno-thyroid, by the *posterior surface of the body* to the triangularis sterni, and by the *ensiform cartilage* to the external oblique, internal oblique, transversalis, rectus, and diaphragm.

RIBS.

The ribs are twelve in number at each side; the first seven are connected with the sternum, and are thence named *sternal* or *true* ribs; the remaining five are the *asternal* or *false* ribs; and the last two, shorter than the rest, and free at their extremities, are the *floating* ribs. The ribs increase in length from the first to the eighth, whence they diminish to the twelfth; in breadth they diminish gradually from the first to the last, and, with the exception of the last two, are broader at the anterior than at the posterior end. The first rib is horizontal in direction; all the rest are oblique, the anterior extremity falling considerably below the posterior. Each rib presents an external and internal surface, a superior and inferior border, and two extremities; it is curved to correspond with the arch of the thorax, and twisted, so that, when laid on a horizontal surface, one end is tilted up.

The **external surface** is convex, and marked by the attachment of muscles; the *internal* is flat, and corresponds with the pleura; the *superior border* is rounded; the *inferior border* is sharp and grooved on its inner edge. The lower edge of the groove giving attachment to the external, and the upper edge to the internal intercostal muscle. Near its vertebral extremity, the rib is somewhat bent; and opposite the bend, on the external surface, is a rough oblique ridge, which gives attachment to a tendon of the sacro-lumbalis muscle, and is called the *angle*. This distance between the vertebral

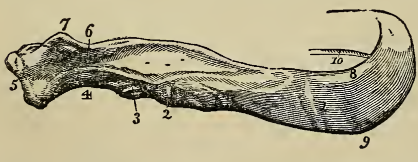


Fig. 124.—Vertebral extremity of the seventh rib of the right side. 1. The angle. 2. The tubercle; rough surface for the posterior costo-transverse ligament. 3. Articular surface. 4. Neck of the rib. 5. Head, presenting two articular facets. 6. Rough surface for the attachment of the middle costo-transverse ligament. 7. Crest for the anterior costo-transverse ligament. 8. Upper rounded border. 9. Lower sharp border. 10. Groove on the inner edge of the lower border.

extremity and the angle increases gradually from the second to the eleventh rib. Beyond the angle is a rough elevation, the *tubercle*, to which the posterior costo-transverse ligament is attached; and immediately at the base and under side of the tubercle a smooth surface for articulation with the extremity of the transverse process

of the corresponding vertebra. The vertebral end of the rib is somewhat expanded, and termed the *head*, and that portion between the head and tubercle, the *neck*. On the extremity of the head is an oval smooth surface divided by a transverse ridge into two facets for articulation with two contiguous vertebræ; the ridge being joined to the intervertebral substance by means of an interarticular ligament. The posterior surface of the neck is rough, for the attachment of the middle costo-transverse ligament; and upon its upper border is a crest, which gives attachment to the anterior costo-transverse ligament. The sternal extremity is flattened, and presents an oval depression for the reception of the costal cartilage.

The ribs that demand especial consideration are the first, tenth, eleventh, and twelfth.

The **first** is the shortest rib; it is broad and flat, and placed horizontally at the upper part of the thorax, the surfaces looking upwards and downwards, in place of forwards and backwards as in the other ribs. At about the anterior third of the upper surface of the bone, and near its internal border, is a tubercle which gives attachment to the scalenus anticus muscle, and immediately before and behind that tubercle, a shallow oblique groove, the former for the subclavian vein, the latter for the subclavian artery. Near the posterior extremity of the bone is a thick and prominent *tubercle*, with a smooth articular surface for the transverse process of the first dorsal vertebra; and between the tubercle and the groove for the subclavian artery is a depression for the attachment of the scalenus medius muscle. There is no angle. Beyond the tubercle is a narrow constricted neck; and at the extremity, a head, presenting a single articular surface. The second rib, in some of its characters, resembles the first.

The **tenth** rib has a single articular surface on its head.

The **eleventh** and **twelfth** have each a single articular surface on the head, no neck or tubercle, and are pointed at the free extremity. The eleventh has a slight ridge, representing the angle, and a shallow groove on the lower border; the twelfth has neither.

Development.—The ribs are developed by *three* centres; one for the central part, one for the head, and one for the tubercle. The last two have no centre for the tubercle. Ossification commences in the body somewhat before its appearance in the vertebræ; the epiphysal centres for the head and tubercle appear between sixteen and twenty, and are consolidated with the rest of the bone at twenty-five.

Articulations.—Each rib articulates with two vertebræ and one costal cartilage, with the exception of the first, tenth, eleventh, and twelfth, which articulate each with a single vertebra only.

Attachment of Muscles.—Intercostal muscles, scalenus anticus, medius, and posticus, pectoralis minor, serratus magnus, obliquus externus, latissimus dorsi, quadratus lumborum, serratus posticus superior, serratus posticus inferior, sacro-lumbalis, longissimus dorsi, cervicalis ascendens, levatores costarum, transversalis, and diaphragm.

COSTAL CARTILAGES.

The costal cartilages serve to prolong the ribs forward to the anterior part of the chest, and contribute mainly to the elasticity of the thorax. They are broad at their attachment with the ribs, and taper slightly towards the sternal end; they diminish gradually in breadth from the first to the last; in length they increase from the first to the seventh, and then decrease to the last. The cartilages of the first two ribs are horizontal in direction, the rest incline more and more upwards. In advanced age the costal cartilages are converted more or less completely into bone, the change taking place earlier in the male than in the female.

The first seven cartilages articulate with the sternum; the three next, with the lower border of the cartilage immediately preceding; the last two lie free between the abdominal muscles. All the cartilages of the false ribs terminate by pointed extremities.

Attachment of Muscles.—Subclavius, sterno-thyroid, pectoralis major, internal oblique, rectus, transversalis, diaphragm, triangularis sterni, internal intercostals.

CLAVICLE.

The clavicle (*clavis*, a key) is a long bone, shaped like the italic letter *ſ*, and extended across the upper part of the side of the chest from the upper piece of the sternum to the point of the shoulder, where it articulates with the scapula. In position it is slightly oblique, the sternal end being somewhat lower and more anterior than the scapular, and the curves are so disposed that at the sternal end the convexity, and at the scapular the concavity, is directed forwards. The sternal half of the bone is rounded, and terminates

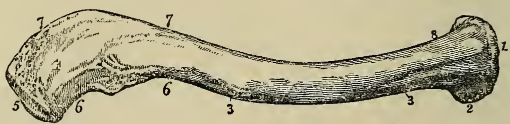
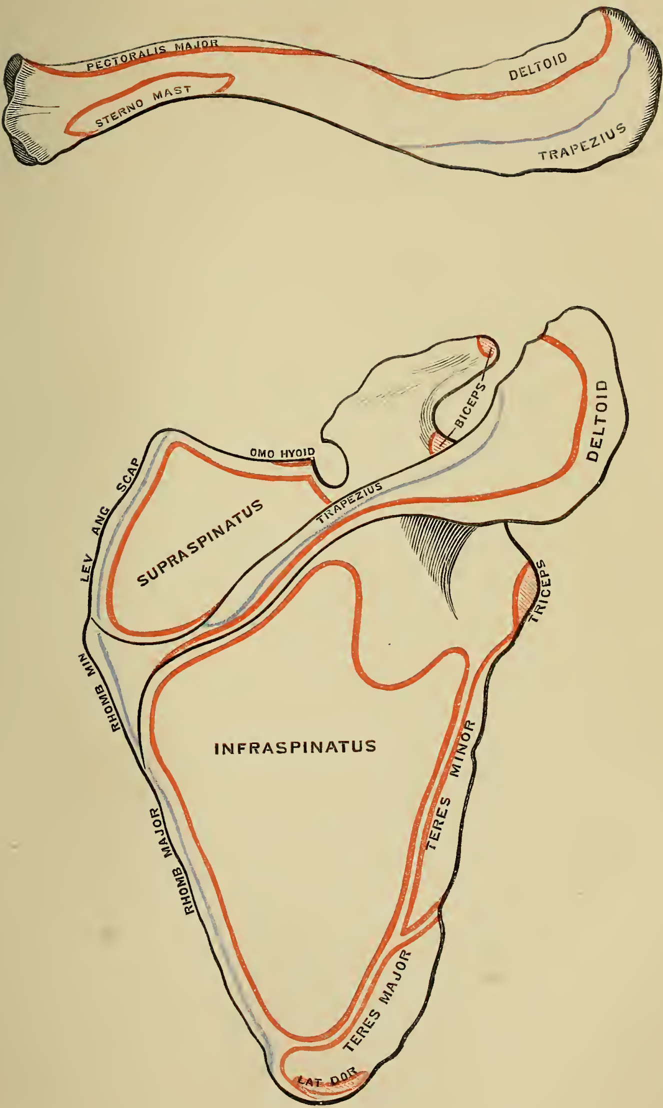


FIG. 125.—Clavicle of the right side; its upper and anterior face. 1. The sternal end. 2. The portion which articulates with the first rib. 3, 3. Ridge of attachment of the pectoralis major. 4. Acromial end. 5. Surface of articulation with the acromion. 6, 6. Ridge for the attachment of the deltoid. 7, 7. Line of insertion of the trapezius. 8. Line of origin of the sterno-mastoid.

in a broad articular facet, which is continued for a short distance on to the under surface. The scapular half is flattened from above downwards, and broad at its extremity, the articular surface occupying only part of its extent. The upper surface is smooth, convex, and partly subcutaneous; the under surface rough and excavated, for the insertion of the subclavius muscle. At the sternal extremity of the under surface is a very rough prominence, which gives attachment to the rhomboid ligament; and at the other extremity a rough

PLATE 7.


PECTORALIS MAJOR
STERNO MAST
DELTOID
TRAPEZIUS
OMO HYOID
BICEPS
DELTOID
LEV ANG SCAP
SUPRASPINATUS
TRAPEZIUS
TRICEPS
RHOMB MIN
INFRASPINATUS
TERES MINOR
RHOMB MAJOR
TERES MAJOR
LAT DOR

tubercle and ridge, for the coraco-clavicular (trapezoid and conoid) ligament. The opening for the nutrient vessels is seen at the under surface of the bone.

Development.—By *two* centres; one for the shaft and one for the sternal extremity; the former appearing before any other bone of the skeleton, the latter between fifteen and eighteen.

Articulations.—With the sternum, scapula, and cartilage of first rib.

Attachment of Muscles.—To *six:* sterno-cleido-mastoid, trapezius, pectoralis major, deltoid, subclavius, and sterno-hyoid.

SCAPULA.

The scapula is a flat triangular bone, situated on the posterior aspect and side of the thorax, and occupying the space from the second to the seventh rib. It is divisible into an anterior and posterior surface; superior, inferior, and posterior border; anterior, superior, and inferior angle; and processes.

The **anterior surface**, or subscapular fossa, is concave and uneven, and marked by several oblique ridges which have a direction upwards and downwards. The concavity is occupied by the subscapularis muscle, with the exception of the posterior border, a triangular surface near the superior angle, and similar area near the inferior angle, these parts giving attachment to the serratus magnus. The **posterior surface**, or dorsum, is convex, and unequally divided into two portions by the spine: that portion above the spine is the supra-spinous fossa; and that below, the infra-spinous fossa.

The **superior border** is the shortest of the three; it is thin and concave, terminated at one extremity by the superior angle, and at the other by the coracoid process. At its humeral end, and formed partly by the base of the coracoid process, is the supra-scapular notch for the transmission of the supra-scapular nerve.

The **inferior** or **axillary border** is thick, and marked by several grooves and depressions; it terminates superiorly at the glenoid cavity, and inferiorly at the inferior angle. Immediately below the glenoid cavity is a rough ridge, which gives origin to the long head of the triceps muscle. In the middle of this border is a depression for the teres minor, and beneath this a deeper groove for the teres major; near the inferior angle is a projecting lip, which increases the surface of origin of the latter muscle.

The **posterior border** or **base**, the longest of the three, is turned towards the vertebral column. It is intermediate in thickness between the superior and inferior, and convex. Attached to it are three muscles, the levator anguli scapulæ extending from the upper edge of the triangular area at the root of the spine to the superior angle, the rhomboideus minor corresponding in its attachment to the triangular area, and the rhomboideus major attached to the rest of the border.

The **anterior angle** is the thickest part of the bone, and forms the *head* of the scapula; it is immediately surrounded by a constricted portion, the *neck.* The head presents a shallow pyriform articular surface, the *glenoid cavity*, having the pointed extremity upwards; and at its apex is a rough depression, which gives attachment to the long tendon of the biceps. At the anterior and upper

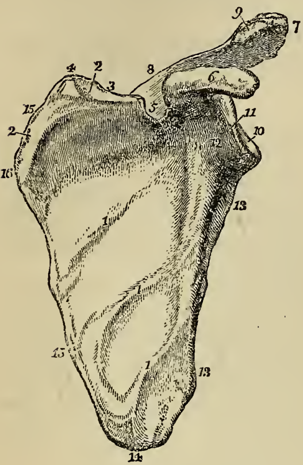


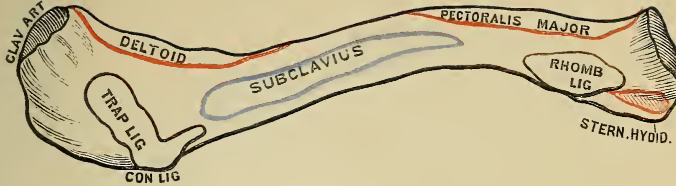
Fig. 126.—Anterior surface or venter of the scapula. 1, 1, 1. Oblique ridges crossing the subscapular fossa. 2, 2. Upper part of the surface occupied by the serratus magnus muscle. 3. Superior border. 4. Superior angle. 5. Supra-scapular notch. 6. Coracoid process. 7. Acromion process. 8. Spine of the scapula; the figure 5, while indicating the supra-scapular notch, is placed on the spine. 9. Articular surface of the acromio-clavicular joint. 10. Glenoid cavity. 11. Head of the scapula. 12. Its neck. 13, 13. Axillary border; the upper 13 is placed against the ridge of the triceps. 14. Inferior angle. 15, 15. Posterior border. 16. Prominence corresponding with the origin of the spine of the scapula.

part of the glenoid cavity a rudimentary notch is observed in its margin, this is interesting as corresponding to the notch at the inner side of the acetabulum. The **superior angle** is thin and pointed. The **inferior angle** is thick, and smooth upon the external surface for the origin of the teres major and for a large bursa over which the upper border of the latissimus dorsi muscle plays; it also occasionally gives origin to a few fibres of the latter muscle.

The **spine** of the scapula, triangular in form, crosses the upper part of the dorsum of the bone; it commences at the posterior border by a smooth triangular surface, over which the fan-shaped tendon of the trapezius glides, and terminates at the point of the shoulder in the acromion process. At a short distance from its origin, where the triangular surface rises to the level of the spine, is a prominent tubercle, which marks the termination of the line of attachment of the tendon of the trapezius. The free border of the spine is rough and subcutaneous, and gives attachment, by two projecting lips, to the trapezius above and deltoid below; the surfaces of the spine enter into the formation of the supra- and infra-spinous fossa. The nutrient foramina of the scapula are situated in the base of the spine.

The **acromion**, somewhat triangular in form, is flattened from

PLATE 8.


CLAV ART
DELTOID
PECTORALIS MAJOR
SUBCLAVIUS
RHOMB LIG
TRAP LIG
STERN.HYOID.
CON LIG


CLAV
COR. BIC
PECT MIN
CON& TRAP LIG
MAGNUS
TRICEPS
SUBSCAPULARIS
SERRATUS

above downwards; it overhangs the glenoid cavity, the upper surface being rough and subcutaneous, the lower smooth. Near its extremity, on the anterior border, is an oval articular surface, for the end of the clavicle.

The **coracoid process** is a thick, round, and curved process of bone, arising from the upper part of the neck of the scapula, and overarching the glenoid cavity. It is about two inches in length, very strong, and gives attachment by its tip to the biceps and coraco-brachialis muscles, and by its anterior border to the pectoralis minor. Near its base is a rough impression for the conoid ligament, and running forwards from this an oblique ridge for the trapezoid ligament.

Development.—By *six* centres; one for the body (including the spine), one for the coracoid process, two for the acromion, one for the inferior angle, and one for the posterior border. The ossific centre for the body appears in the infra-spinous fossa at about the same time as the ossification of the vertebræ; for the coracoid process during the first year; the acromion process at puberty; the inferior angle in the fifteenth year; and the posterior border at seventeen or eighteen. There is frequently a second centre for the coracoid process, which appears near the supra-scapular notch about the seventeenth year. Union between the coracoid process and body takes place during the fifteenth year; the bone is not complete till after the twenty-second year.

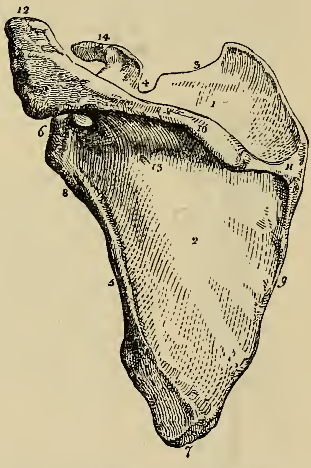


Fig. 127.—Posterior view of the scapula. 1. Supra-spinous fossa. 2. Infra-spinous fossa. 3. Superior border. 4. Supra-scapular notch. 5. Axillary border. 6. Head of the scapula and glenoid cavity. 7. Inferior angle. 8. Neck of the scapula; the ridge opposite the figure gives origin to the long head of the triceps. 9. Posterior border or base of the scapula. 10. The spine. 11. Triangular smooth surface, over which the tendon of the trapezius glides. 12. Acromion process. 13. One of the nutrient foramina. 14. Coracoid process.

Articulations.—With the clavicle and humerus.

Attachment of Muscles.—To *sixteen;* by its *anterior surface* to the subscapularis and serratus magnus; *posterior surface*, supra-spinatus and infra-spinatus; *superior border*, omo-hyoid; *posterior border*, levator anguli scapulæ, rhomboideus minor, rhomboideus major; *axillary border*, long head of the triceps, teres minor, teres major; *upper angle of the glenoid cavity*, long tendon of the biceps; *spine and acromion*, trapezius and deltoid; *coracoid process*, pectoralis minor, short head of the biceps, and coraco-brachialis. The liga-

ments attached to the coracoid process are, coraco-acromial, coraco-clavicular, coraco-humeral, and the costo-coracoid membrane.

HUMERUS.

The humerus is a long bone, and is therefore divisible into a shaft and two extremities.

The **upper extremity** presents a rounded *head;* a constriction immediately around the base of the head, the *neck;* a *greater* and a *lesser tuberosity.* The greater tuberosity is situated most externally, and is marked by three facets for the insertion of the supra-spinatus, infra-spinatus, and teres minor muscles. The lesser tuberosity, placed internally, gives attachment to the tendon of the subscapularis. The tuberosities are separated by a vertical furrow, the *bicipital groove,* which lodges the long tendon of the biceps. The edges of this groove below the head of the bone are prominent and rough, and called the *external* and *internal bicipital ridges;* the former serves

Fig. 128.

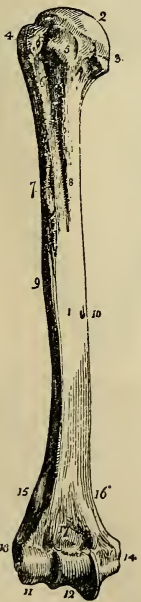


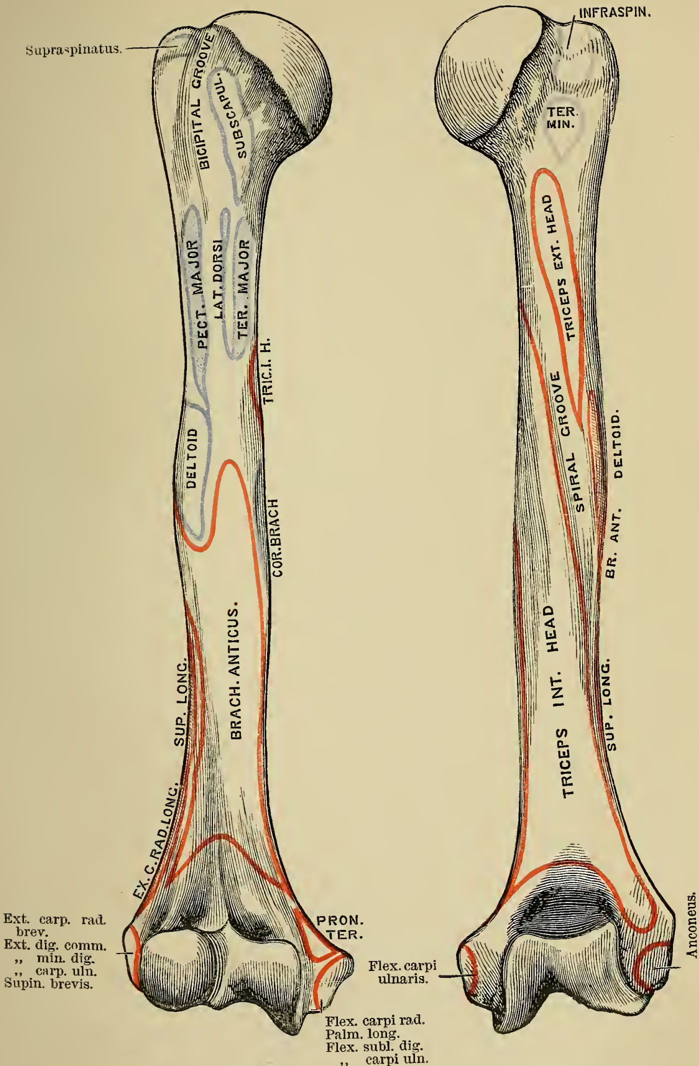
Fig. 128.—Humerus of the right arm; its anterior surface. 1. Shaft of the bone. 2. Head. 3. Anatomical neck. 4. Greater tuberosity. 5. Lesser tuberosity. 6. Bicipital groove. 7. External bicipital ridge. 8. Internal bicipital ridge. 9. Rough surface into which the deltoid is inserted. 10. Nutrient foramen. 11. Eminentia capitata. 12. Trochlea. 13. External condyle. 14. Internal condyle. 15. External condylar ridge. 16. Internal condylar ridge. 17. Fossa for the coronoid process of the ulna.

Fig. 129.

Fig. 129.—Humerus of the right arm; its posterior aspect. 1. Shaft. 2. Head. 3, 3. Neck. 4, 4. Surgical neck. 5. Great tuberosity. 6. Facets of insertion of the infra-spinatus and teres minor. 7. Groove for the musculo-spiral nerve. 8. Articular surface of the elbow. 9. Internal condyle. 10. External condyle. 11. External condylar ridge. 12. Fossa for the reception of the olecranon.

for the insertion of the pectoralis major muscle, the latter for the tendon of the teres major; at the bottom of the groove the tendon of the latissimus dorsi is inserted.

PLATE 9.



Supraspinatus.
BICIPITAL GROOVE
SUBSCAPUL.
PECT. MAJOR
LAT. DORSI
TER. MAJOR
TRIC.I. H.
DELTOID
COR.BRACH
BRACH. ANTICUS.
SUP. LONG.
EX.C.RAD.LONG.
Ext. carp. rad. brev.
Ext. dig. comm.
,, min. dig.
,, carp. uln.
Supin. brevis.
PRON. TER.
Flex. carpi rad.
Palm. long.
Flex. subl. dig.
,, carpi uln.
INFRASPIN.
TER. MIN.
TRICEPS EXT. HEAD
SPIRAL GROOVE
DELTOID.
BR. ANT.
TRICEPS INT. HEAD
SUP. LONG.
Anconeus.
Flex. carpi ulnaris.

The constriction of the bone below the tuberosities is the surgical neck, and is so named, in contradistinction to the true neck, from being the seat of the accident called by surgical writers *fracture of the neck of the humerus.*

The **shaft** of the bone is prismoid at its upper part, and flattened from before backwards below. On the outer side, at about its middle, is a rough triangular eminence, which gives insertion to the deltoid; and immediately on each side of this eminence is a smooth depression, corresponding with the two heads of the brachialis anticus. On the inner side of the middle of the shaft is a smooth surface for the attachment of the coraco-brachialis muscle; and behind, an oblique and shallow groove, which lodges the musculo-spiral nerve and superior profunda artery. The foramen for the medullary vessels is situated on the inner surface of the shaft of the bone a little below the coraco-brachial impression; it is directed downwards.

The **lower extremity** is flattened from before backwards, and terminated inferiorly by a long articular surface, divided into two parts by an elevated ridge. The external portion of the articular surface is a rounded protuberance, *eminentia capitata*, which articulates with the cup-shaped depression on the head of the radius; the internal portion is a concave and pulley-like surface, *trochlea*, for articulation with the ulna. Projecting beyond the articular surface at each side are the *external* and *internal condyle*, the latter being considerably the longer; and running upwards from the condyles along the borders of the bone are the condylar ridges, of which the external is the most prominent. Immediately in front of the trochlea is a small depression for receiving the coronoid process of the ulna during flexion of the fore-arm (coronoid fossa); and immediately behind it a large and deep fossa, for containing the olecranon process during extension (olecranon fossa).

Development.—By *seven* centres; one for the shaft, one for the head, one for the tuberosities, one for the eminentia capitata, one for the trochlea, and one for each condyle, the internal preceding the external. Ossification commences in the diaphysis of the humerus soon after the clavicle; in the head and tuberosities, during the second and third year of infantile life; in the eminentia capitata and trochlea during the third and eleventh year; and in the condyles during the fifth and fifteenth. At the time of birth the shaft is ossified, but the extremities are cartilaginous; the centre for the head and that for the tuberosities unite during the fifth year. The entire bone is consolidated at twenty.

Articulations.—With the glenoid cavity of the scapula, the ulna, and radius.

Attachment of Muscles.—To *twenty-four:* by the *greater tuberosity*, supra-spinatus, infra-spinatus, and teres minor; *lesser tuberosity*, subscapularis; *external bicipital ridge*, pectoralis major; *internal bicipital ridge and groove*, teres major and latissimus dorsi; *shaft*, external and internal head of the triceps, deltoid, coraco-brachialis,

and brachialis anticus ; *external condylar ridge and condyle* (extensor condyle), extensors and supinators of the fore-arm, viz., supinator longus, extensor carpi radialis longior, extensor carpi radialis brevior, extensor communis digitorum, extensor minimi digiti, extensor carpi ulnaris, anconeus, and supinator brevis ; *internal condyle* (flexor condyle), flexors and one pronator, viz. pronator radii teres, flexor carpi radialis, palmaris longus, flexor sublimis digitorum, and flexor carpi ulnaris.

ULNA.

The ulna is a long bone, divisible into a shaft and two extremities. The upper extremity is large, and forms principally the articulation of the elbow ; the lower extremity is small, and is excluded from the wrist-joint by an interarticular fibrocartilage.

The **upper extremity** presents a semilunar concavity of large size, the *greater sigmoid notch*, for articulation with the humerus ; and on the outer side a *lesser sigmoid notch*, for the head of the radius. Bounding the greater sigmoid notch posteriorly is the *olecranon process ;* and, overhanging it in front, a pointed eminence with a rough triangular base, the *coronoid process.* Behind the lesser sigmoid notch, and extending downwards on the side of the olecranon, is a triangular uneven surface for the anconeus muscle ; and on the posterior surface of the olecranon a smooth triangular surface, which is subcutaneous. The olecranon gives attachment by its tip to the triceps muscle.

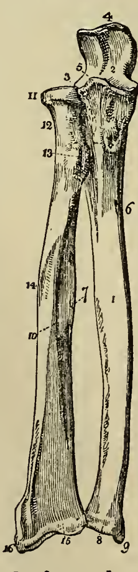
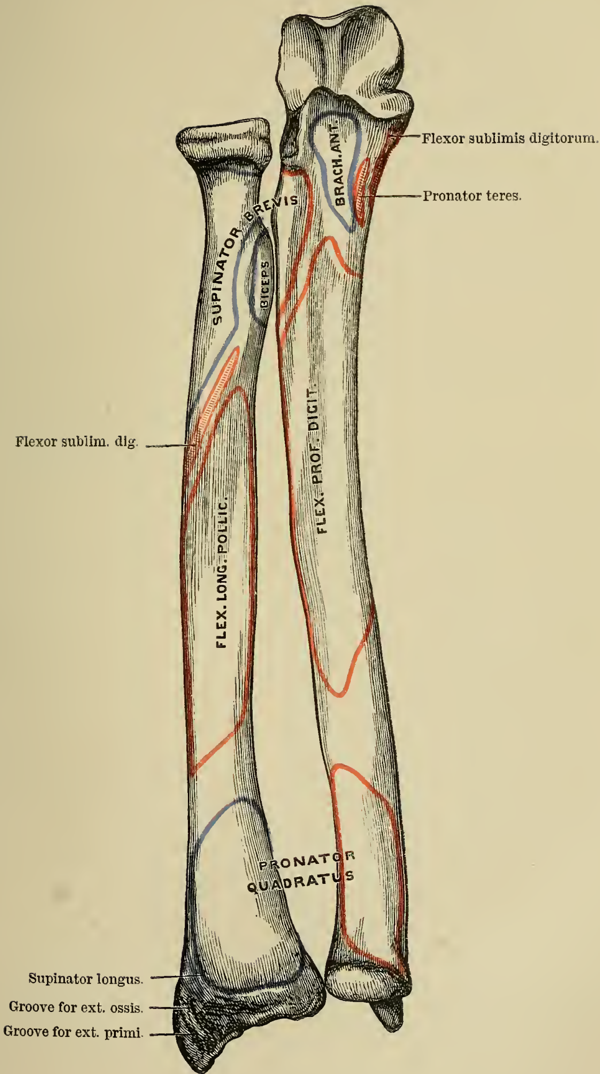


FIG. 130.—The two bones of the fore-arm seen from the front. 1. Shaft of the ulna. 2. Greater sigmoid notch. 3. Lesser sigmoid notch, with which the head of the radius is articulated. 4. Olecranon process. 5. Coronoid process. 6. Nutrient foramen. 7. The sharp ridges upon the two bones to which the interosseous membrane is attached. 8. Capitulum ulnæ. 9. Styloid process. 10. Shaft of the radius. 11. Its head surrounded by the smooth border for articulation with the orbicular ligament. 12. Neck of the radius. 13. Its tubercle. 14. The oblique line. 15. Lower extremity of the bone. 16. Styloid process.

The **shaft** is prismoid in form, and presents three surfaces, anterior, posterior, and internal ; and three borders. The *anterior surface* is occupied by the flexor profundus digitorum for the upper three-fourths of its extent ; and below, by a depression for the pronator quadratus muscle. A little above its middle is the nutrient foramen, directed upwards. On the *posterior surface*, at the upper part of the bone, is the triangular uneven depression for the anconeus muscle, bounded inferiorly by an oblique ridge which runs downwards from the posterior extremity of the lesser sigmoid notch. Below the ridge, the surface is marked into several grooves for the attachment of the extensor ossis metacarpi, extensor

PLATE 10.



Flexor sublimis digitorum.
Pronator teres.
BRACH. ANT.
SUPINATOR BREVIS
BICEPS
Flexor sublim. dig.
FLEX. PROF. DIGIT.
FLEX. LONG. POLLIC.
PRONATOR QUADRATUS
Supinator longus.
Groove for ext. ossis.
Groove for ext. primi.

secundi internodii, and extensor indicis muscle. The *internal surface* is covered in for the greater part of its extent by the flexor profundus digitorum. The *anterior border* is rounded, and gives origin by its lower fourth to the pronator quadratus. The *posterior* is prominent, and affords attachment to the flexor carpi ulnaris and extensor carpi ulnaris; expanding at the upper extremity into the triangular subcutaneous surface of the olecranon. The *external* or *radial border* is sharp and prominent, for the attachment of the interosseous membrane.

The **lower extremity** terminates in a small rounded head, *capitulum ulnæ*, from the side of which projects the *styloid process.* The latter presents a deep notch at its base for the attachment of the apex of the triangular interarticular cartilage, and by its point gives attachment to the internal lateral ligament. On the posterior surface of the head is a groove, for the tendon of the extensor carpi ulnaris; and on the side opposite the styloid process a smooth surface, for articulation with the side of the radius.

Development.—By *three* centres; one for the shaft, one for the inferior extremity, and one for the tip of the olecranon. Ossification commences in the ulna shortly after the humerus and radius; the ends of the bone are cartilaginous at birth. The centre for the lower end appears at about the fifth, that for the tip of the olecranon about the tenth, year. The upper epiphysis joins the shaft about the sixteenth year, and the lower epiphysis joins about the twentieth.

Articulations.—With *two* bones; humerus and radius; it is separated from the cuneiform bone of the carpus by the triangular interarticular cartilage.

Attachment of Muscles.—To *thirteen:* by the *olecranon* to the triceps, one head of the flexor carpi ulnaris, and anconeus; by the *coronoid process*, brachialis anticus, pronator radii teres, flexor sublimis digitorum, and flexor profundus digitorum; by the *shaft*, flexor profundus digitorum, flexor carpi ulnaris, pronator quadratus, supinator brevis, anconeus, extensor carpi ulnaris, extensor ossis metacarpi pollicis, extensor secundi internodii pollicis, and extensor indicis.

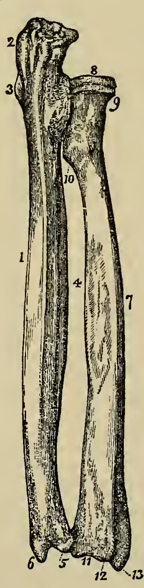


FIG. 131.—Bones of the fore-arm, seen on their posterior aspect. 1. Shaft of the ulna. 2. Olecranon process. 3. Border of the great sigmoid notch. 4. Ridge on radius and ulna for the interosseous membrane. 5. Capitulum ulnæ. 6. Styloid process. 7. Shaft of the radius. 8. Its head. 9. Neck. 10. Tuberosity. 11. Lower extremity of the bone. 12. Ridge separating the tendons of the extensors in their passage to the dorsum of the hand. 13. Styloid process.

RADIUS.

The radius is the rotatory bone of the fore-arm; it is divisible into a shaft and two extremities: unlike the ulna, its upper extremity is small, and merely accessory to the formation of the elbow-joint; while the lower extremity is large, and forms almost solely the joint of the wrist.

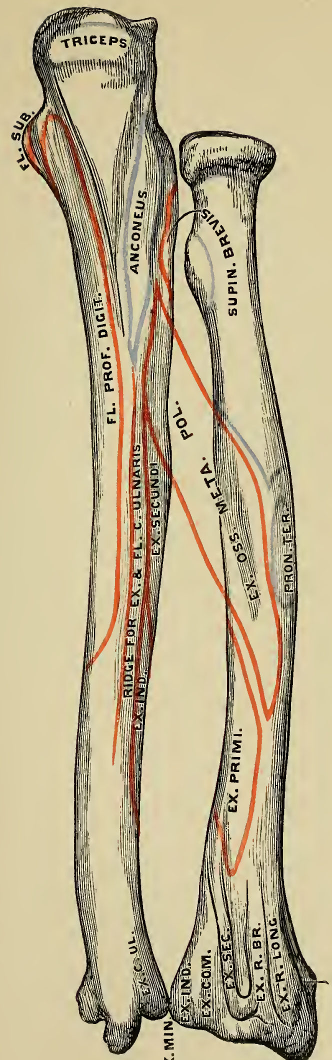
The **upper extremity** presents a rounded *head*, depressed on its upper surface into a shallow cup. Around the margin of the head is a smooth articular surface which is broad on the inner side, where it articulates with the lesser sigmoid notch of the ulna, and narrow in the rest of its circumference, to play in the orbicular ligament. Beneath the head is a constricted circular *neck*; and beneath the neck, on its internal aspect, a prominent process, the *tuberosity*. The surface of the tuberosity is partly smooth and partly rough: rough behind, where it receives the attachment of the tendon of the biceps; and smooth in front, where a bursa is interposed between the tendon and the bone.

The **shaft** of the bone is prismoid, and presents three surfaces. The *anterior surface* is somewhat concave superiorly, where it lodges the flexor longus pollicis; and flat below, where it supports the pronator quadratus. At about the upper third of this surface is the nutrient foramen, which is directed upwards. The *posterior surface* is round above, where it supports the supinator brevis muscle, and marked below by several shallow oblique grooves, which afford attachment to the extensor muscles of the thumb. The *external surface* is round and convex, and marked in its middle by a rough impression for the insertion of the pronator radii teres; it is separated from the anterior surface by a marked ridge, the upper part of which has been named the *oblique ridge*, and gives attachment to the flexor sublimis digitorum. On the *inner margin* is a sharp and prominent crest, which gives attachment to the interosseous membrane.

The **lower extremity** of the radius is broad and triangular, and provided with two articular surfaces; one at the side of the bone, which is concave to receive the rounded head of the ulna; the other at the extremity, and marked by a slight ridge into two facets, one external and triangular, corresponding with the scaphoid; the other square, with the semilunar bone. At the outer side of the extremity is a strong conical projection, the *styloid process*, which gives attachment by its base to the tendon of the supinator longus, and by its apex to the external lateral ligament of the wrist-joint. The inner edge of the terminal articular surface affords attachment to the base of the triangular interarticular fibro-cartilage of the ulna.

Immediately in front of the styloid process is a groove, which lodges the tendons of the extensor ossis metacarpi pollicis and extensor primi internodii; and, behind the process, a broader groove, frequently divided by a slight ridge, for the tendons of the extensor carpi radialis longior and brevior; behind this is a prominent ridge,

PLATE 11.



Groove for ext. ossis, metac. poll., and ext. primi internod. poll.

and a deep narrow groove, for the tendon of the extensor secundi internodii pollicis; and internal to this, another broad groove for the tendons of the extensor communis digitorum, and extensor indicis: the extensor minimi digiti running in a groove at the point of articulation of the radius and ulna.

Development.—By *three* centres; one for the shaft, and one for each extremity. Ossification commences in the shaft soon after the humerus, and before the ulna. The inferior centre appears during the second year, the superior about the fifth. The upper epiphysis unites about puberty, the lower about the age of twenty.

Articulations.—With *four* bones: humerus, ulna, scaphoid, and semilunar.

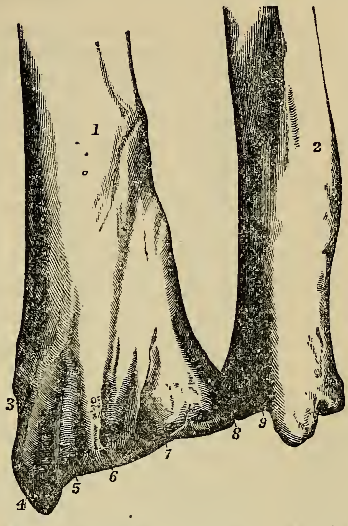


FIG. 132.—Grooves at the back of the radius and ulna. 1. Radius. 2. Ulna. 3. Groove for extensor ossis metacarpi and extensor primi internodii pollicis. 4. Groove for extensor carpi radialis longior. 5. For extensor carpi radialis brevior. 6. For extensor secundi internodii pollicis. 7. For extensor communis digitorum and extensor indicis. 8. For extensor minimi digiti. 9. For extensor carpi ulnaris.

Attachment of Muscles.—To *nine:* by the *tuberosity* to the biceps; by the *oblique ridge*, supinator brevis, flexor sublimis digitorum; by the *anterior surface*, flexor longus pollicis and pronator quadratus; by the *external surface*, pronator radii teres; by the *posterior surface*, extensor ossis metacarpi pollicis and extensor primi internodii; and by the *styloid process*, supinator longus.

CARPUS.

The bones of the carpus are eight in number, arranged in two rows, consisting of four bones each: those of the proximal row, enumerating from the radial side, are the scaphoid, semilunar, cuneiform, and pisiform; those of the distal row, in the same order, are the trapezium, trapezoid, os magnum, and unciform.

With the exception of the semilunar, they all have the dorsal surface broad and convex, and the palmar contracted; the semilunar differs from the rest, in that its dorsal surface is narrow and flattened, and its palmar surface broad and convex. The proximal articulating surface is usually convex, and the distal concave.

SCAPHOID.

This bone is named from bearing some slight resemblance to the shape of a boat, being broad at one end, and narrowed like a prow at the opposite; concave on one side, and convex on the other. It is, however, more similar in form to a cashew nut flattened and concave on one side. If carefully examined, it will be found to present *proximally* a large convex articular surface, which fits into the outer part of the cupped extremity of the radius; *distally* it is bluntly pointed, and has two smooth surfaces, divided by a slight ridge, for articulation, the outer with the trapezium, and the inner with the trapezoid. Its *internal* (ulnar) surface is concave, and presents two articular facets, one shallow and crescentic for the semilunar, the other circular and deeply excavated for receiving the head of the os magnum. The proximal portion of the *palmar* surface is depressed and concave, the distal portion is raised above the level of the rest of the bone, forming a marked prominence, to which the anterior annular ligament is attached. The *dorsal* surface is convex from side to side, contracted from above downwards, and grooved for the attachment of ligaments. The *external* surface is narrow, non-articular, and rough for the attachment of fibres of the external lateral ligament.

Recognition.*—To ascertain the hand to which the bone belongs:—hold it with the palmar prominence upwards, and the proximal extremity directed backwards; the narrow, non-articular, external surface will point to the hand to which the bone belongs.

Articulations.—With *five* bones: radius, semilunar, trapezium, trapezoid, and os magnum.

Attachment of Muscles.—No muscles are attached directly to this bone.

SEMILUNAR.

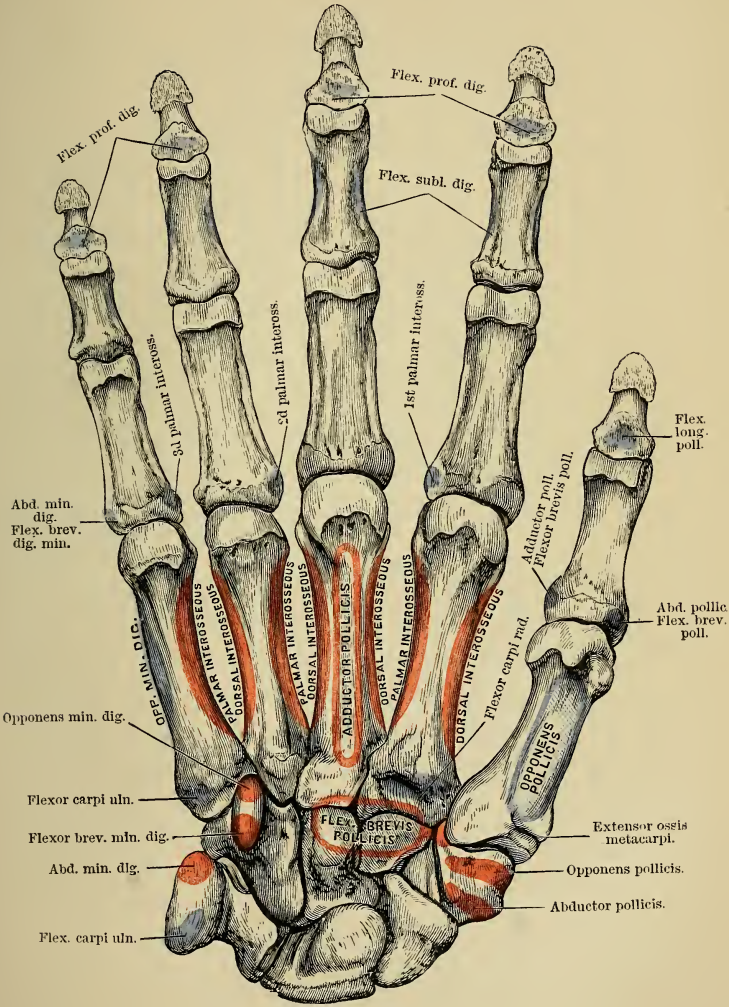
This bone may be known by its crescentic figure. The *dorsal* surface is narrow and flat, the *palmar* broad and rounded. The other surfaces are all articular; they are as follows:—

The *proximal*, large and convex, occupies the second depression on the inferior articulating surface of the radius; the *distal*, concave, articulates with the head of the os magnum; the *external*, crescentic, corresponds with a like surface on the scaphoid; and the *internal*, nearly circular, articulates with the cuneiform. Sometimes it articulates also with the unciform, in which case the last-named articulating surface is divided into two parts by a slight ridge.

Recognition.—If the bone be held with the broad palmar sur-

* In referring each bone to its appropriate hand the same system is to be followed throughout the series; it consists in placing the bone in the position it occupies in the hand, namely, with the narrow palmar surface upwards, and the proximal surface (usually convex) looking backwards; the outer surface then points to the side to which the bone belongs.

PLATE 12.


Flex. prof. dig.
Flex. prof. dig.
Flex. subl. dig.
3d palmar inteross.
2d palmar inteross.
1st palmar inteross.
Flex. long. poll.
Adductor poll.
Flexor brevis poll.
Abd. min. dig.
Flex. brev. dig. min.
OPP. MIN. DIG.
PALMAR INTEROSSEOUS
DORSAL INTEROSSEOUS
PALMAR INTEROSSEOUS
DORSAL INTEROSSEOUS
ADDUCTOR POLLICIS
DORSAL INTEROSSEOUS
PALMAR INTEROSSEOUS
DORSAL INTEROSSEOUS
Flexor carpi rad.
Abd. pollic.
Flex. brev. poll.
OPPONENS POLLICIS
Opponens min. dig.
Flexor carpi uln.
FLEX. BREVIS POLLICIS
Flexor brev. min. dig.
Extensor ossis metacarpi.
Abd. min. dig.
Opponens pollicis.
Abductor pollicis.
Flex. carpi uln.

face upwards, and the convex proximal articulating surface directed backwards, the crescentic articular facet will point to the appropriate hand.

Articulations.—With *four* or *five* bones: radius, scaphoid, os magnum, cuneiform, and sometimes the unciform.

Attachment of Muscles.—No muscles are attached to this bone.

CUNEIFORM.

This bone, although somewhat wedge-shaped in form, may be best distinguished by a circular and isolated facet, which articulates with the pisiform bone. Its *palmar* surface is narrow and rough externally for the attachment of ligaments, internally it presents the characteristic facet for the pisiform just referred to. The *dorsal* surface is broad and rough for ligamentous attachment.

The *distal* end of the cuneiform bone has a broad smooth surface for articulation with the unciform; the *proximal* surface is partly rough for the attachment of ligaments, and partly smooth for articulation with the triangular fibrocartilage. The *outer* side is marked by a circular facet corresponding to the one on the inner side of the semilunar; the *inner* surface is rough, and gives attachment to ligaments.

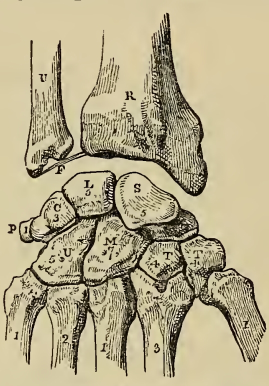


FIG. 133.—Diagram showing the dorsal surface of the bones of the carpus, with their articulations. The right hand:—R. Lower end of radius. U. Lower end of ulna. F. Interarticular fibrocartilage, attached to the styloid process of the ulna, and to the margin of the articular surface of the radius. S. Scaphoid bone. L. Semilunar. P. Pisiform. T. Trapezium. T. Trapezoid. M. Os magnum. U. Unciform. The figures both on the carpal and metacarpal bones refer to the number of bones with which they articulate.

Recognition.—Hold the bone with the broad dorsal surface downwards, and the broad articular surface directed forwards; the circular articular facet for the semilunar will point to the hand to which the bone belongs.

Articulations.—With three bones: semilunar, pisiform, and unciform; and with the triangular fibrocartilage of the wrist-joint.

Attachment of Muscles.—To none.

PISIFORM.

This bone may be recognised by its small size, and by the possession of only one articular facet. Examined carefully, it will be observed to present four sides and two extremities; one side is

articular, the smooth facet approaching nearer to the proximal than to the distal extremity. The side opposite to this is rounded; the remaining sides are, one slightly concave, the other slightly convex.

Recognition.—If the bone be held so that the extremity which overhangs the articular facet is directed forwards, and the concave surface upwards, the articular facet will point to the hand to which the bone belongs.

Articulations.—With the cuneiform bone only.

Attachment of Muscles.—To two: flexor carpi ulnaris, and abductor minimi digiti; and to the anterior annular ligament.

TRAPEZIUM.

This bone is too irregular in form to be compared to any known object; and may be distinguished by a deep groove for the tendon of the flexor carpi radialis muscle, and by the saddle-shaped distal articular facet. Its *palmar* surface is marked by this groove, and by a prominent tubercle which overhangs it, which gives attachment to the abductor, flexor brevis, and flexor ossis metacarpi pollicis muscles, and to the anterior annular ligament. The *proximal* extremity of the trapezium has a facet for articulation with the scaphoid,

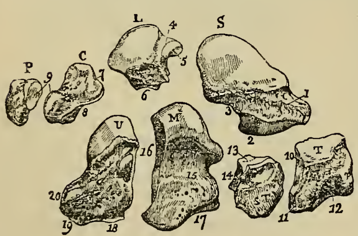


FIG. 134.—Bones of the carpus of the right hand, separated so as to show the form of the individual bones. S. Scaphoid: the letter is placed over the surface which articulates with the radius. 1. Its dorsal surface. 2. Surface to articulate with the trapezium and trapezoid, the two facets divided by a ridge. 3. Concave articulating surface for the head of the os magnum. L. Semilunar: the letter is placed over the surface which articulates with the radius. 4. Surface to articulate with the scaphoid. 5. Surface to articulate with the head of the os magnum. 6. Border of the surface which articulates with the unciform. C. Cuneiform. 7. Surface to articulate with the semilunar. 8. Surface to articulate with the unciform. P. Pisiform. 9. Articular facet. T. Trapezium: the letter is placed on the surface which articulates with the scaphoid. 10. Surface to articulate with the trapezoid. 11. Articulating surface for the metacarpal bone of the index finger. 12. Articulating surface for the metacarpal bone of the thumb. TZ. Trapezoid. 13. Articulating surface for the scaphoid. 14. Articulating surface for the os magnum. M. Os magnum: the letter is placed on the head of the bone. 15. Rough surface of the dorsum of the bone. 16. Articulating surface for the unciform. 17. Articulating surface for the metacarpal bone of the middle finger. U. Unciform: the letter is placed on the surface which articulates with the semilunar and cuneiform. 18. Articulating surface for the ring finger. 19. Articulating surface for the little finger. 20. Rough point forming part of the free border of the carpus.

and its *distal* extremity one of large size, concave from side to side, convex from above downwards, for articulation with the metacarpal bone of the thumb. *Internally* it presents two articular facets—the upper, large and concave, for the trapezoid; the lower, small and

flat, for the extremity of the second metacarpal bone. Its *dorsal* and *external* surfaces are rough for ligamentous attachments.

Recognition.—If the bone be held with the grooved surface upwards, and the surface with two facets forwards, the saddle-shaped surface will point to the hand to which the bone belongs.

Articulations.—With *four* bones: scaphoid, trapezoid, and two first metacarpals.

Attachment of Muscles.—To three: abductor pollicis, flexor brevis pollicis, and flexor ossis metacarpi pollicis.

TRAPEZOID.

This bone is small, oblong, quadrilateral, and bent near its middle (bean-shaped). Its *dorsal* surface is wide and convex, its *palmar* very narrow and flattened. It has four articular surfaces separated by slight ridges; the proximal of these is quadrilateral, and articulates with the scaphoid; the *distal* one is saddle-shaped for the second metacarpal bone; the *internal* surface is smooth and concave for the os magnum, and the *external* is convex for the trapezium.

Recognition.—Hold the bone with the narrow free surface upwards, and the saddle-shaped surface looking forwards; the convex articular surface will point to the appropriate hand.

Articulations.—With *four* bones: trapezium, os magnum, scaphoid, and second metacarpal.

Attachment of Muscles.—Part of the flexor brevis pollicis.

OS MAGNUM.

This is the largest bone of the carpus; it is divisible into a head or *proximal*, and a body or *distal* extremity. The rounded head articulates by its proximal and external surfaces with the semilunar and scaphoid bones. Its *palmar* and *dorsal* surfaces are both rough; the latter being square and flat, the former rounded and prominent. Its *distal* extremity is divided into three small facets for articulation with the second, third, and fourth metacarpal bones; its *internal* surface is rough distally for an interosseous ligament, smooth proximally for articulation with the unciform. By its *external* surface it articulates by means of a small facet with the trapezoid, and proximal to this facet is a rough space for another interosseous ligament. The proximal articular surface encroaches on the external surfa e but not on the internal, so that the former is easily identified by this peculiarity.

Recognition.—If the bone be held with the flat and rough dorsal surface downwards, and the head directed backwards, the side of the head on to which the proximal articular facet is continued will point to the appropriate hand.

Articulations.—With *seven* bones: scaphoid, semilunar, trapezoid, unciform, and the second, third, and fourth metacarpal bones.

Attachment of Muscles.—Part of the flexor brevis pollicis.

UNCIFORM.

This is a triangular-shaped bone, remarkable for a long and curved process, which projects from its palmar aspect. The *palmar* surface is free, and is distinguished by the hooked process just mentioned; the *dorsal* surface is broad and rough. Its *distal extremity* presents a double articular surface for the fourth and fifth metacarpal bones; its *proximal* extremity is convex for articulation with the semilunar; *externally* it has two facets, with an intervening rough space, these being for articulation with the os magnum; and *internally* it has an oblong smooth facet for the cuneiform.

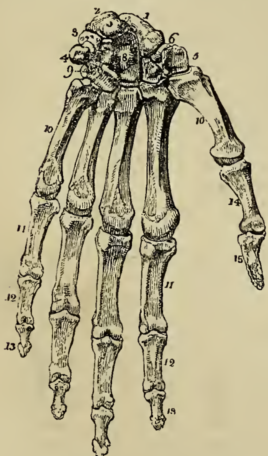


FIG. 135.—Left hand viewed on its anterior or palmar aspect. 1. Scaphoid bone. 2. Semilunar. 3. Cuneiform. 4. Pisiform. 5. Trapezium. 6. Groove in the trapezium which lodges the tendon of the flexor carpi radialis. 7. Trapezoid. 8. Os magnum. 9. Unciform. 10, 10. The five metacarpal bones. 11, 11. First row of phalanges. 12, 12. Second row. 13, 13. Third row, or ungual phalanges. 14. First phalanx of the thumb. 15. Second and last phalanx of the thumb.

Recognition.—If the bone be held with the uncinate process upwards, and the double facet forwards, the two small articular surfaces, with the intervening rough portion, will point to the appropriate hand.

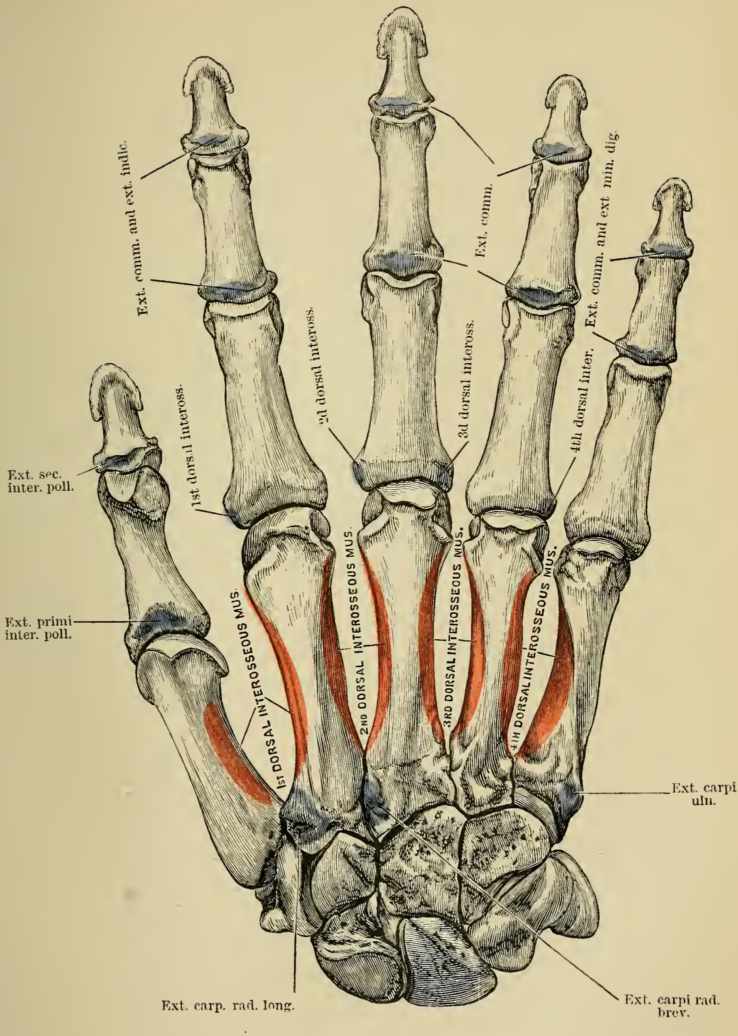
Articulation.—With *five* bones: semilunar, os magnum, cuneiform, and fourth and fifth metacarpals.

Attachment of Muscles. — To *two:* flexor ossis metacarpi minimi digiti and flexor brevis minimi digiti; and to the anterior annular ligament.

Development of the Carpus.—The bones of the carpus are each developed by a single centre; they are cartilaginous at birth. Ossification commences towards the end of the first year in the os magnum and unciform; at the end of the third year, in the cuneiform; during the fifth year, in the trapezium and semilunar; during the sixth, in the scaphoid; eighth, in the trapezoid; and twelfth, in the pisiform. The latter bone is the last in the skeleton to ossify; it is, in reality, a sesamoid bone of the tendon of the flexor carpi ulnaris.

The number of articulations which each bone of the carpus maintains with surrounding bones may be expressed in figures, which will facilitate the student's recollection; the cipher for the first row is 5531, and for the second 4475.

PLATE 13.



Ext. comm. and ext. indic.
Ext. comm.
Ext. comm. and ext min. dig.
2d dorsal inteross.
3d dorsal inteross.
1st dorsal inteross.
4th dorsal inter.
Ext. sec. inter. poll.
Ext. primi inter. poll.
1ST DORSAL INTEROSSEOUS MUS.
2ND DORSAL INTEROSSEOUS MUS.
3RD DORSAL INTEROSSEOUS MUS.
4TH DORSAL INTEROSSEOUS MUS.
Ext. carpi uln.
Ext. carp. rad. long.
Ext. carpi rad. brev.

METACARPUS.

The bones of the metacarpus are five in number. They are long bones, divisible into a head, shaft, and base.

The *head* is rounded at the extremity, and flattened at each side for the insertion of strong ligaments; the *shaft* is prismoid, and marked deeply on each side for the attachment of the interossei muscles; the *base* is irregularly quadrilateral, and rough for the insertion of tendons and ligaments. The *base* presents three articular surfaces: one at each side for adjoining metacarpal bones, and one at the extremity for the carpus.

The *metacarpal bone of the thumb* is one-third shorter than the rest, flattened and broad on its dorsal aspect, and convex on its palmar side; the articular surface of the head is not so round as that of the other metacarpal bones; and the base has a single proximal saddle-shaped surface, to articulate with the corresponding surface of the trapezium. It has no lateral facets.

The metacarpal bones of the different fingers may be distinguished by certain special characters. The base of the *metacarpal bone of the index finger* is the largest of the four, and presents four articular surfaces; it may most readily be identified by its proximal articular surface being divided into two, so as to present a notched appearance. That of the *middle finger* may be distinguished by a rounded projecting process at the radial side of its base (styloid process), and two small circular facets on its ulnar lateral surface. The base of the *metacarpal bone of the ring finger* is small and square, and has two small circular facets to correspond with those of the middle metacarpal. The *metacarpal bone of the little finger* has only one lateral articular surface.

Development.—By *two* centres; one for the shaft, and one for the digital extremity, with the exception of the metacarpal bone of the thumb, the epiphysis of which, like that of the phalanges, occupies the carpal end of the bone. Ossification of the metacarpal bones commences in the embryo during the eighth or ninth week, that is, soon after the bones of the fore-arm. The epiphyses make their appearance at the end of the second or early in the third year, and the bones are completed at twenty.

Articulations.—The *first* with the trapezium; *second*, trapezium, trapezoid, os magnum, and middle metacarpal; *third* or middle, os magnum, and adjoining metacarpal bones; *fourth*, os magnum, unciform, and adjoining metacarpal bones; *fifth*, unciform, and metacarpal bone of the ring finger.

The figures representing the number of articulations which each metacarpal bone has with the bones of the carpus, taken from the radial to the ulnar side, are 13121.

Attachment of Muscles.—To the metacarpal bone of the thumb, *three*, flexor ossis metacarpi, extensor ossis metacarpi, and first dorsal interosseous; index finger, *six*, extensor carpi radialis longior, flexor

brevis pollicis, flexor carpi radialis, first and second dorsal and first palmar interosseous; middle finger, *five*, extensor carpi radialis brevior, flexor brevis pollicis, adductor pollicis, second and third dorsal interosseous; ring finger, *three*, third and fourth dorsal interosseous, and second palmar; little finger, *four*, extensor carpi ulnaris, flexor ossis metacarpi minimi digiti, fourth dorsal and third palmar interosseous.

PHALANGES.

The phalanges (internodia) are the bones of the fingers; they are named from their arrangement in rows, and are fourteen in number, three to each finger, and two to the thumb. In conformation they are long bones, divisible into a shaft and two extremities.

The *shaft* is compressed from before backwards, convex on its posterior surface, and flat with raised edges in front. The metacarpal extremity or *base* in the first row is a simple concave articular surface; that in the other two rows a double concavity, separated by a slight ridge. The digital extremities of the first and second row present a pulley-like surface, concave in the middle, and convex at each side. The ungual extremity of the last phalanx is broad, rough, and expanded into a semilunar crest.

Development.—By *two* centres; one for the shaft, and one for the base. Ossification commences in the third or ungual phalanges, then in the first, and lastly in the second. The period of commencement corresponds with that of the metacarpal bones. The epiphyses of the first row appear during the third or fourth year, those of the second row during the fourth or fifth, and of the last during the sixth or seventh. The phalanges are perfected by the twentieth year.

Articulations.—The first row, with the metacarpal bones and second row of phalanges; the second row, with the first and third; the third, with the second row.

Attachment of Muscles.—To the base of the *first phalanx* of the thumb *four* muscles, abductor pollicis, flexor brevis pollicis, adductor pollicis, and extensor primi internodii; to the *second phalanx*, *two*, flexor longus pollicis, and extensor secundi internodii. To the *first phalanx* of the second, third, and fourth fingers, one dorsal and one palmar interosseous; to that of the little finger, abductor minimi digiti, flexor brevis minimi digiti, and one palmar interosseous. To the *second phalanges*, flexor sublimis and extensor communis digitorum; to the *last phalanges*, flexor profundus and extensor communis digitorum.

PELVIS AND LOWER EXTREMITY.

The bones of the pelvis are the two ossa innominata, the sacrum, and the coccyx; and those of the lower extremity, the femur, patella, tibia and fibula, tarsus, metatarsus, and phalanges.

OS INNOMINATUM.

The os innominatum (os coxæ) is an irregular, flat bone, consisting in the young subject of three parts, which meet at the acetabulum. Hence it is described in the adult as divisible into three portions, ilium, ischium, and pubes. The *ilium* is the superior, broad, and expanded portion which forms the prominence of the hip, and articulates with the sacrum. The *ischium* is the inferior and strong part of the bone on which the body rests in sitting. The *pubes* is that portion which forms the front of the pelvis, and gives support to the external organs of generation.

The Ilium may be described as divisible into an internal and external surface, a crest, and an anterior and posterior border.

The **internal surface** is bounded above by the crest, below by a prominent line, the *pectineal line*, and before and behind by the anterior and posterior border; it is concave and smooth for the anterior two-thirds of its extent, and lodges the iliacus muscle. The posterior third is rough, for articulation with the sacrum, and divided by a deep groove into two parts; an anterior or *auricular*

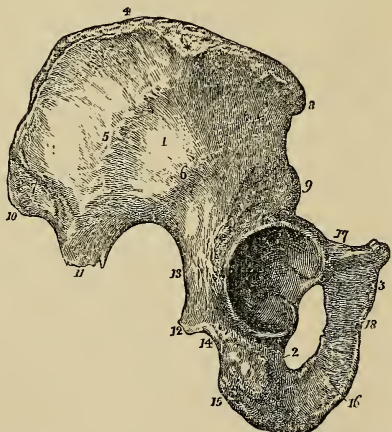


Fig. 136.—Os innominatum of the right side. 1. Ilium; its external surface. 2. Ischium. 3. Pubes. 4. Crest of the ilium. The * is situated upon the widest portion of the crest of the ilium. 5. Middle curved line. 6. Inferior curved line. 7. Surface for the gluteus maximus, and superior curved line. 8. Anterior superior spinous process. 9. Anterior inferior spinous process. 10. Posterior superior spinous process. 11. Posterior inferior spinous process. 12. Spine of the ischium. 13. Great sacro-ischiatic notch. 14. Lesser sacro-ischiatic notch. 15. Tuberosity of the ischium, showing its three facets. 16. Ramus of the ischium. 17. Body of the pubes. 18. Ramus of the pubes.

portion, shaped like the pinna of the ear, and coated by cartilage in the fresh bone; and a posterior portion, very rough and uneven, for the attachment of interosseous ligaments.

The **external surface** is uneven, partly convex, and partly concave: it is bounded above by the crest; below by a prominent arch, which forms the upper segment of the acetabulum; and, before and behind, by the anterior and posterior border. At the posterior part, a rough line marks off a triangular area which gives attachment to the gluteus maximus; the line is continued anteriorly into the

outer lip of the crest, and is called the *superior curved line.* Near the middle of this surface is a second ridge which is called the *middle curved line;* it commences near the anterior superior spine, and terminates in the upper part of the greater sacro-ischiatic notch. Below this is a third ridge called the *inferior curved line*, commencing just above the anterior inferior spine, and terminating at the lower part of the greater sacro-ischiatic notch. The surface included between the superior and middle curved lines gives origin to the gluteus medius muscle; that between the middle and inferior curved lines, to the gluteus minimus; and the rough interval between the inferior curved line and the arch of the acetabulum, to one head of the rectus.

The **crest** of the ilium is arched, and curved in direction like the italic letter *ʃ*, being bent inwards at its anterior termination, and outwards at the posterior. It is broad for the attachment of three planes of muscle, which are connected with its external and internal border or lip, and with the intermediate space. On its outer lip, at about midway between the anterior superior spinous process and the summit of the crest, is a prominent tubercle, from which a strong ridge runs down to the acetabulum. This is the broadest part of the crest, and the descending ridge serves as a buttress in giving strength to the bone.

The **anterior border** is marked by two prominences, the *anterior superior spinous process*, which is the anterior termination of the crest, and the *anterior inferior spinous process;* the first of these and the space beneath it give attachment to the sartorius muscle, the second to one head of the rectus. This border terminates inferiorly in the lip of the acetabulum. The **posterior border** also presents two prominences, the *posterior superior* and *posterior inferior spinous process*, separated by a notch; the former gives attachment to the oblique sacro-iliac ligament, the latter to the greater sacro-ischiatic ligament. Inferiorly this border is broad and arched, and forms the upper part of the great sacro-ischiatic notch.

The Ischium is divisible into a thick and solid portion, the **body**, and a thin and ascending part, the **ramus**; it may be considered also, for convenience of description, as presenting an external and internal surface, and three borders, posterior, inferior, and superior.

The **external surface** is rough and uneven for the attachment of muscles; and broad and smooth above, where it enters into the formation of the acetabulum. Below the inferior lip of the acetabulum is a notch which lodges the obturator externus muscle in its passage outwards to the trochanteric fossa of the femur. The **internal surface** is smooth, and somewhat encroached upon at its posterior border by the spine; it is separated by the pectineal line from the concave inner surface of the ilium, and is chiefly occupied by the origin of the obturator internus.

The **posterior border** of the ischium presents towards its middle a remarkable projection, the *spine*, which is directed backwards and inwards, and gives origin by its inner surface to two muscles, the

coccygeus and levator ani. Immediately above the spine is a notch of large size, the *great sacro-ischiatic*, and below the spine, the *lesser sacro-ischiatic notch;* the former, being converted into a foramen by the lesser sacro-ischiatic ligament, gives passage to the gluteal vessels and nerve, pyriformis muscle, pudic vessels and nerve, and ischiatic vessels and nerves; the lesser, completed by the great sacro-ischiatic ligament, to the obturator internus muscle, the nerve which is distributed to it, and internal pudic vessels and nerve. The **inferior border** is thick and broad, and called the *tuberosity*. The surface of the tuberosity is divided into three facets; one anterior, which is rough for the origin of the semi-membranosus; and two posterior, which are smooth and separated by a slight ridge, for the semi-tendinosus and biceps muscle. The inner margin of the tuberosity is bounded by a sharp ridge, which gives attachment to a prolongation of the great sacro-ischiatic ligament; and the outer margin by a prominent ridge, from which the quadratus femoris muscle arises. The **superior border** of the ischium is thin, and forms the lower circumference of the obturator foramen. The **ramus** of the ischium is continuous with the ramus of the pubes, and is slightly everted.

The Pubes is divided into a horizontal portion or **body** (horizontal ramus of Albinus), and a descending portion or **ramus**; it presents for examination an external and internal surface, superior and inferior border, and symphysis.

The **external surface** is rough for the attachment of muscles; and prominent at its outer extremity, where it forms part of the acetabulum. The **internal surface** is smooth, and enters into the formation of the cavity of the pelvis. The **superior border** is marked by a rough ridge, the *crest;* the inner termination of the crest is the *angle;* the outer end, the *spine;* the latter gives attachment to the inner end of Poupart's ligament. Running outwards from the spine is a sharp ridge, the *pectineal line*, which marks the brim of the true pelvis. In front of the pectineal line is a smooth depression, which supports the femoral artery and vein, and a little more externally an elevated prominence, the *pectineal eminence*, which divides the surface for the femoral vessels from another depression which overhangs the acetabulum, and lodges the psoas and iliacus muscle. The pectineal eminence, moreover, marks the junction of the pubes with the ilium. The **inferior border** is broad, deeply grooved for the passage of the obturator vessels and nerve, and sharp on the side of the ramus, to form part of the boundary of the obturator foramen. The *symphysis* is the inner extremity of the body of the bone; it is oval and rough for the attachment of the articular cartilage. The **ramus** of the pubes descends obliquely outwards, and is continuous with the ramus of the ischium. The inner border of the ramus forms with the corresponding bone the *arch of the pubes*, and at its inferior part is everted, to give attachment to the crus penis. The ramus of the ischium and pubes together give attachment by their external surface to the adductor longus, brevis, and magnus muscles, the gracilis and obturator internus, and

by their internal surface to the compressor urethræ, erector penis, transversus perinei, and levator ani.

The **acetabulum** (cotyloid cavity) is a deep cup-shaped cavity, situated at the point of union between the ilium, ischium, and pubes; a little less than two-fifths being formed by the ilium, a little more than two-fifths by the ischium, the remaining fifth by the pubes. It is bounded by a deep rim or lip, broad and strong above, where most resistance is required, and marked in front by a deep notch, which is arched over in the fresh subject by a strong ligament, and transmits the nutrient vessels of the joint. At the bottom of the cup, and communicating with the notch, is a deep circular pit, which lodges a mass of fat, and gives attachment by its edges to the broad extremity of the ligamentum teres.

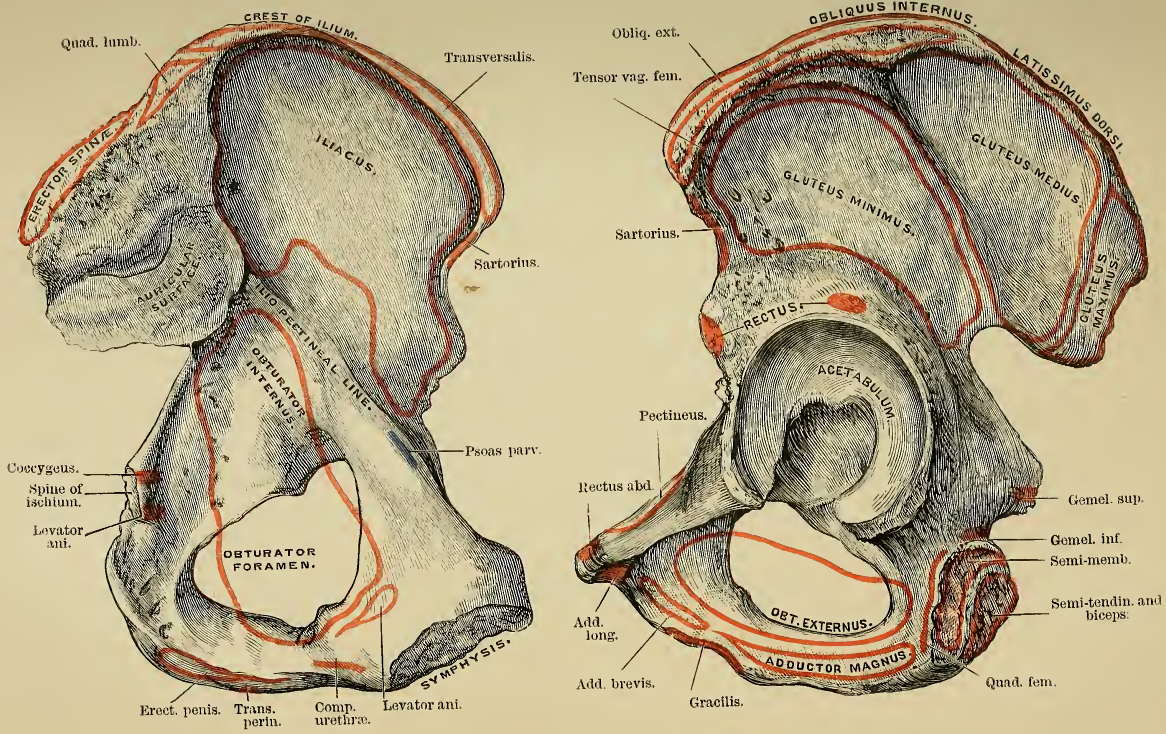
The **obturator** or **thyroid foramen** is a large oval interval between the ischium and pubes, bounded by a narrow rough margin, to which a ligamentous membrane is attached. The upper part of the foramen is increased in depth by the groove in the under surface of the os pubis, which lodges the obturator vessels and nerve.

Development.—By *eight* centres: three principal, one for the ilium, one for the ischium, and one for the pubes; and five secondary, one, the Y-shaped piece, for the interval between the primitive pieces in the bottom of the acetabulum, one for the crest of the ilium, one (not constant) for the anterior and inferior spinous process of the ilium, one for the tuberosity of the ischium, and one (not constant) for the angle of the pubes. Ossification commences in the primitive pieces, immediately after that in the vertebræ, firstly in the ilium during the eighth week, then in the ischium in the third month, and lastly in the pubes in the fourth or fifth month; the first ossific deposits being situated near the future acetabulum. At birth, the acetabulum, crest of the ilium, and ramus of the pubes and ischium, are cartilaginous. The rami of the ischium and pubes unite during the eighth year. The epiphyses appear about the time of puberty, that for the Y-shaped cartilage ossifying first; the three parts of the bone unite in the acetabulum at about the seventeenth or eighteenth year, and the bone is completed from the twenty-third to the twenty-fifth year.

Articulations.—With *three* bones; sacrum, opposite innominate, and femur.

Attachment of Muscles and Ligaments.—To *thirty-four* muscles: to the ilium *thirteen;* by the *outer lip of the crest*, obliquus externus for two-thirds its length, latissimus dorsi one-third, and tensor vaginæ femoris its anterior fourth; by the *middle of the crest*, internal oblique three-fourths its length, erector spinæ the remaining fourth; by the *internal lip*, transversalis three-fourths, and quadratus lumborum the posterior part of its middle third. By the *external surface*, gluteus medius, minimus, maximus, and one head of the rectus; by the *internal surface*, iliacus; by the *anterior border*, sartorius, and the other head of the rectus. To the ischium *fourteen;* by its *external surface*, adductor magnus and obturator externus; by

PLATE 14.



CREST OF ILIUM.
Quad. lumb.
Transversalis.
ERECTOR SPINÆ.
ILIACUS.
AURICULAR SURFACE.
Sartorius.
ILIO PECTINEAL LINE.
OBTURATOR INTERNUS.
Psoas parv.
Coccygeus.
Spine of ischium.
Levator ani.
OBTURATOR FORAMEN.
SYMPHYSIS.
Erect. penis.
Trans. perin.
Comp. urethræ.
Levator ani.
OBLIQUUS INTERNUS.
Obliq. ext.
LATISSIMUS DORSI.
Tensor vag. fem.
GLUTEUS MEDIUS.
GLUTEUS MINIMUS.
Sartorius.
GLUTEUS MAXIMUS.
RECTUS.
ACETABULUM.
Pectineus.
Rectus abd.
Gemel. sup.
Gemel. inf.
Semi-memb.
Semi-tendin. and biceps.
OBT. EXTERNUS.
ADDUCTOR MAGNUS.
Add. long.
Add. brevis.
Gracilis.
Quad. fem.

the *internal surface*, obturator internus and levator ani; by the *spine*, gemellus superior, levator ani, coccygeus, and lesser sacro-ischiatic ligament; by the *tuberosity*, biceps, semi-tendinosus, semi-membranosus, gemellus inferior, quadratus femoris, erector penis, and great sacro-ischiatic ligament; by the *ramus*, gracilis, and transversus perinei. To the os pubis *seventeen;* by its *upper border*, obliquus externus, obliquus internus, transversalis, rectus, pyramidalis, pectineus, and psoas parvus; by its *external surface*, adductor longus, adductor brevis, gracilis, and obturator externus; by its *internal surface*, levator ani and obturator internus; and by the *ramus*, adductor magnus, erector penis, accelerator urinæ, and compressor urethræ.

PELVIS.

The pelvis is formed by the union of four bones, namely, the two innominate bones, sacrum, and coccyx. It is divisible into a false

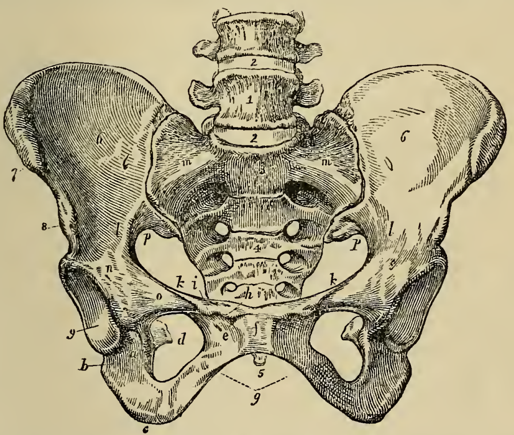


FIG. 137.—Female pelvis. 1. Last lumbar vertebra. 2, 2. Intervertebral substance connecting the last lumbar vertebra with the fourth and sacrum. 3. Promontory of the sacrum. 4. Anterior surface of the sacrum, on which its transverse lines and foramina are seen. 5. Tip of the coccyx. 6, 6. Iliac fossæ, forming the lateral boundaries of the false pelvis. 7. Anterior superior spinous process of the ilium; right side. 8. Anterior inferior spinous process. 9. Acetabulum. *a.* Notch of the acetabulum. *b.* Body of the ischium. *c.* Its tuberosity. *d.* Spine of the ischium seen through the obturator foramen. *e.* Pubes. *f.* Symphysis pubis. *g.* Arch of the pubes. *h.* Angle of the pubes. *i.* Spine of the pubes; the prominent ridge between *h* and *i* is the crest of the pubes. *k, k.* Pectineal line of the pubes. *l, l.* Pectineal line. *m, m.* The prolongation of this line to the promontory of the sacrum. The line represented by *h. i, k, k, l, l,* and *m, m,* is the brim of the true pelvis. *n.* Pectineal eminence. *o.* The smooth surface which supports the femoral vessels. *p, p.* Great sacro-ischiatic notch.

and true pelvis; the former is the expanded portion, bounded on each side by the ilium, and separated from the true pelvis by the

pectineal line. The true pelvis is all that portion which is situated below this line, which thus forms the margin or **brim** of the true pelvis, while the included area is called the **inlet.** The form of the inlet is heart-shaped, obtusely pointed in front at the symphysis pubis, expanded on each side, and encroached upon behind by a projection of the upper part of the sacrum, which is named the promontory. The cavity is somewhat encroached upon at each side by a smooth quadrangular plane of bone, corresponding with the internal surface of the acetabulum, and prolonged posteriorly into the spine of the ischium. In front are two fossæ around the obturator foramina, for lodging the obturator internus muscle at each side. The inferior termination of the pelvis is very irregular, and is termed the **outlet.** It is bounded, in front, by the convergence of the rami of the ischium and pubes, which constitute the arch of the pubes; on each side by the tuberosity of the ischium, and two irregular fissures formed by the greater and lesser sacro-ischiatic notches; and behind by the lateral borders of the sacrum, and the coccyx.

The pelvis is placed obliquely with regard to the trunk of the body, the inner surface of the pubes being directed upwards, and serving to support the weight of the abdominal viscera. The base of the sacrum rises nearly four inches above the level of the upper border of the symphysis pubis, and the apex of the coccyx somewhat more than half an inch above its lower border. If a line were carried through the central axis of the inlet, it would impinge by one extremity against the umbilicus, and by the other against the middle of the coccyx. The **axis of the inlet** is, therefore, directed *upwards and forwards*, while that of the **outlet** points *downwards and forwards*, and corresponds with a line drawn from the upper part of the sacrum, through the centre of the outlet. The axis of the cavity represents a curve, corresponding very nearly with the curve of the sacrum, the extremities being indicated by the central points of the inlet and outlet. A knowledge of the direction of these axes is important to the surgeon, as indicating the line in which instruments should be used in operations upon the viscera of the pelvis, and the direction of force in the

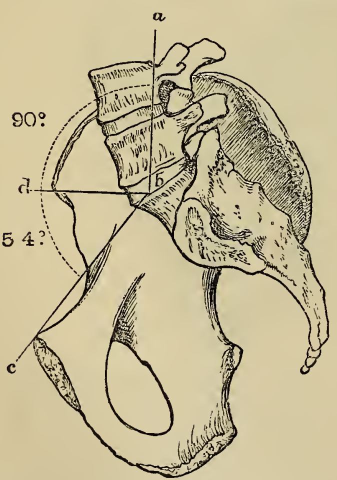


FIG. 138.—Angle of inclination of the pelvis, 144°.

removal of calculi from the bladder; and to the accoucheur, as explaining the course taken by the fœtus during parturition.

There are certain characteristic differences between the male and female pelvis. In the male the bones are thicker, stronger, and more solid, the cavity being deeper and narrower. In the female the bones are lighter and more delicate, the iliac fossæ large, and the ilia expanded; the inlet, outlet, and cavity are large, and the acetabula farther removed from each other; the cavity is shallow, the tuberosities widely separated, the obturator foramina triangular, the sacrum broader and less curved, the coccyx more movable, and the span of the pubic arch greater. The precise diameter of the inlet and outlet, and the depth of the cavity of the female pelvis, are important considerations to the accoucheur.

Three diameters are usually described in each part of the true pelvis, they are: (1) Antero-posterior or conjugate; (2) Transverse; and (3) Oblique. The following table shows the comparative measurements in the male and female pelvis in inches.

	Male.			Female.		
	Brim.	Cavity.	Outlet.	Brim.	Cavity.	Outlet.
Antero-posterior diameter	4	4½	3¼	4½	5¼	5
Transverse diameter	4½	4½	3½	5¼	5	4¾
Oblique diameter	4¼	4½	4	5	5¼	4¾

FEMUR.

The femur, the longest bone of the skeleton, is situated obliquely in the upper part of the lower limb, articulating by means of its head with the acetabulum, and inclining inwards as it descends, until it almost meets its fellow of the opposite side at the knee. In the female this obliquity is greater than in the male, in consequence of the greater breadth of the pelvis. The femur is divisible into a shaft, a superior, and an inferior extremity.

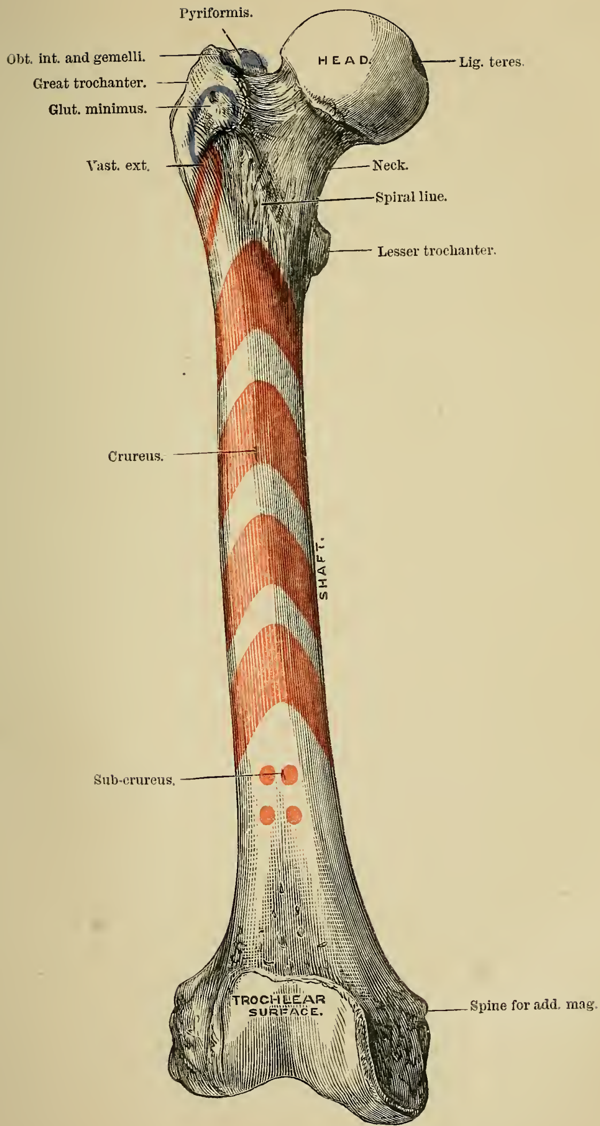
At the **upper extremity** is a rounded *head* directed upwards and inwards, and marked just below its centre by an oval depression for the ligamentum teres. The head is supported by a *neck*, which varies in length and obliquity with sex and period of life, being long and oblique in the adult male, shorter and more horizontal in the female and in old age. Externally to the neck is a large process, the *trochanter major*, which presents on its anterior surface an oval facet, for the attachment of the tendon of the gluteus minimus muscle; and on its outer surface, an oblique line for the insertion of the gluteus medius. On its posterior side is a vertical ridge (*quadrate line*) for the attachment of the quadratus femoris muscle. At the inner side of the trochanter major is a deep pit, *trochanteric* or *digital fossa*, at the bottom of which the obturator externus muscle is

inserted. The upper border of the great trochanter gives attachment near its anterior extremity to the gemellus superior, obturator internus, and gemellus inferior muscles, and a little behind this to the pyriformis muscle. Passing downwards from the trochanter major in front of the bone is an oblique ridge, which forms the inferior boundary of the neck, the *spiral line*, which if traced downwards will be found to lead into the upper part of the linea aspera; in well-marked specimens, two small tubercles will be found on it, one near the great trochanter, and the other lower down; they are called the *external* and *internal cervical tubercles.* Behind there is another oblique ridge, the *intertrochanteric line*, which terminates in a rounded tubercle on the posterior and inner side of the bone, the *trochanter minor*, for the insertion of the psoas and iliacus.

The **shaft** of the femur is convex and round in front, and covered with muscles; and somewhat concave and raised into a rough and prominent ridge behind, the *linea aspera.* The linea aspera near the upper extremity of the bone divides into three branches. The anterior branch is continued forwards in front of the lesser trochanter, and is continuous with the spiral line; the middle is continued directly upwards into the lesser trochanter; and the posterior, broad and strongly marked, ascends to the base of the trochanter major. Towards the lower extremity of the bone the linea aspera divides into two ridges, which descend to the two condyles, and enclose a triangular space upon which rests the popliteal artery. The internal condylar ridge is less marked than the external, and presents a broad and shallow groove for the passage of the femoral artery. The nutrient foramen is situated in or near the linea aspera, at about one-third from its upper extremity, and is directed obliquely from below upwards. The outer side of the shaft immediately above the condyles is very much thicker than the inner side, a point to be borne in mind in division of the femur for the cure of knock-knee.

FIG. 139. — The right femur, seen on its anterior aspect. 1. The shaft. 2. The head. 3. The neck. 4. Great trochanter. 5. Spiral line. 6. Lesser trochanter. 7. External condyle. 8. Internal condyle. 9. Tuberosity for the attachment of the external lateral ligament. 10. Fossa for the tendon of origin of the popliteus muscle. 11. Tuberosity for the attachment of the internal lateral ligament.

PLATE 15.


Pyriformis.
Obt. int. and gemelli.
Great trochanter.
Glut. minimus.
HEAD.
Lig. teres.
Vast. ext.
Neck.
Spiral line.
Lesser trochanter.
Crureus.
SHAFT.
Sub-crureus.
TROCHLEAR SURFACE.
Spine for add. mag.

The **lower extremity** of the femur is broad and porous, and divided by a smooth depression in front, and by a large fossa (intercondylar fossa) behind, into two condyles.

The **external condyle** is the broadest and most prominent, the internal the narrowest and longest; the difference in length depending on the obliquity of the femur, in consequence of the separation of the two bones at their upper extremity by the breadth of the pelvis. The difference in the length of the condyles has been ascertained to amount to about eight millimetres, this being the average of a hundred observations. The external condyle is marked on its outer side by a prominent tuberosity, which gives attachment to the external lateral ligament; and immediately beneath this is the fossa which lodges the tendon of origin of the popliteus. By the internal surface it gives attachment to the anterior crucial ligament of the knee-joint; and by its upper and posterior part, to the external head of the gastrocnemius and plantaris. The **internal condyle** projects on its inner side into a tuberosity, to which is attached the internal lateral ligament; above this tuberosity, at the extremity of the internal condylar ridge, is a tubercle for the insertion of the tendon of the adductor magnus; and below the tubercle, on the upper surface of the condyle, a depression from which the internal head of the gastrocnemius arises. The outer side of the internal condyle is rough and concave, for the attachment of the posterior crucial ligament.

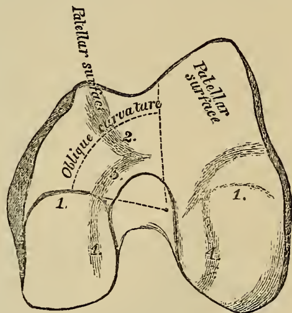


FIG. 140.—Diagram of under surface of condyles of femur.

The lower articular surface of the femur is divisible into three parts, the two *condylar* surfaces, and the *patellar* surface; the latter is marked off from the two former by shallow depressions running from the free margins of the articulation into the upper part of the intercondylar notch. In addition to the true condylar surface, the internal condyle has on its anterior face a small *oblique* surface, interposed between the condylar and patellar surfaces. The patellar or trochlear surface is the anterior part of the articular surface; its outer side extends higher up than its inner, and terminates by a more salient edge.

Development.—By *five* centres; one for the shaft, one for each extremity, and one for each trochanter. The femur is the first of the long bones to show signs of ossification; ossific matter is found immediately after the maxillæ and before the termination of the second month of embryonic life. The secondary deposits take place in the following order: in the condylar extremity* during the last

* Cruveilhier remarks that this centre is so constant in the last fortnight of fœtal life, that it may be regarded as an important proof of the fœtus having reached its full term.

month of fœtal life ; in the head towards the end of the first year ; in the greater trochanter between the third and fourth year ; in the lesser trochanter between the thirteenth and fourteenth. The epiphyses are joined to the diaphysis in the reverse order of their appearance, the junction commencing after puberty, and not being completed for the condylar epiphysis until after the twentieth year.

Articulations.—With *three* bones : os innominatum, tibia, and patella.

Attachment of Muscles.—To *twenty-three :* by the *greater trochanter*, to the gluteus medius and minimus, pyriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and quadratus femoris ; by the *lesser trochanter*, to the common tendon of the psoas and iliacus. By the *linea aspera*, its outer lip, to the vastus externus, gluteus maximus, and short head of the biceps ; by its inner lip, vastus internus, pectineus, adductor brevis, and adductor longus ; by its middle lip, adductor magnus ; by the *anterior part* of the bone, cruræus and subcruræus ; by its *condyles*, gastrocnemius, plantaris, and popliteus.

PATELLA.

The patella is a sesamoid bone, developed in the tendon of the quadriceps extensor muscle, and usually described as a bone of the lower extremity. It is heart-shaped in figure, the broad end being directed upwards, the apex downwards ; the external surface is convex, and the internal divided by a ridge into two smooth surfaces, to articulate with the condyles of the femur. The external articular surface, corresponding with the external condyle, is the larger of the two, and serves to indicate the leg to which the bone belongs. Each surface presents a faint transverse line near its lower end, another near its upper border, so as to divide them into three facets ; the internal surface has also a vertical line near its inner edge. To the upper border are attached the rectus femoris and crureus muscles, and to the upper part of the lateral margins the expanded tendons of the vastus externus and internus, and by the inferior pointed process it is attached, through means of a strong band called the *ligamentum patellæ*, to the tubercle of the tibia.

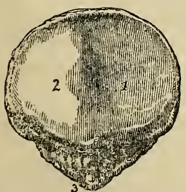


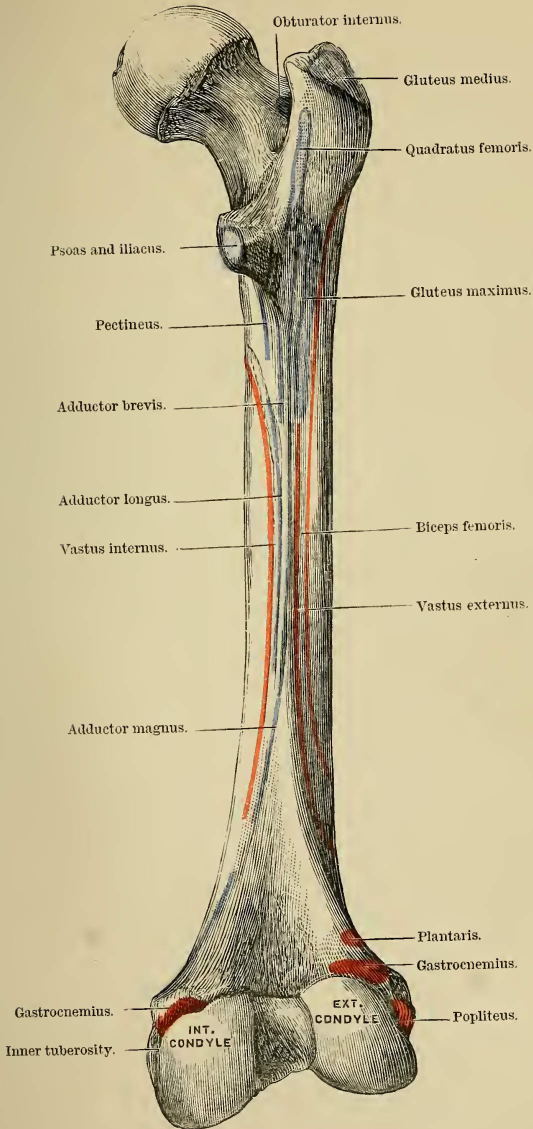
Fig. 141.—Patella of the right side. 1. Surface of articulation with the external condyle of the femur. 2. Surface of articulation with the internal condyle. 3. Apex of the bone.

Development.—By a single centre, at about the middle of the third year.

Articulations.—With the two condyles of the femur.

Attachment of Muscles.—To *four :* rectus, cruræus, vastus internus, vastus externus ; and to the ligamentum patellæ.

PLATE 16.


Obturator internus.
Gluteus medius.
Quadratus femoris.
Psoas and iliacus.
Gluteus maximus.
Pectineus.
Adductor brevis.
Adductor longus.
Biceps femoris.
Vastus internus.
Vastus externus.
Adductor magnus.
Plantaris.
Gastrocnemius.
Gastrocnemius.
EXT. CONDYLE
Popliteus.
INT. CONDYLE
Inner tuberosity.

TIBIA.

The tibia is the inner and larger bone of the leg; it is prismoid in form, and divisible into a shaft, an upper and lower extremity.

The **upper extremity**, or head, is large, and expanded laterally into two *tuberosities.* On the upper surface the tuberosities are smooth to articulate with the condyles of the femur; the internal articular surface being oval to correspond with the internal condyle; the external, broad and nearly circular. Between the two articular surfaces is a *spinous process*; and in front of and behind the spinous process a rough depression, giving attachment to the anterior and posterior crucial ligament. Between the two tuberosities on the front aspect of the bone is a prominent elevation, the *tubercle* for the insertion of the ligamentum patellæ, and immediately above the tubercle a smooth facet, corresponding with the bursa of the ligamentum patellæ. Upon the outer side of the external tuberosity is an articular surface for the head of the fibula; and upon the posterior part of the internal tuberosity a depression for the insertion of the tendon of the semi-membranosus muscle.

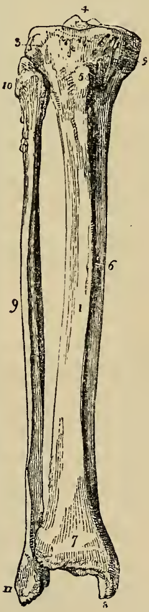


FIG. 142.—Tibia and fibula of the right leg, articulated and seen from the front. 1. Shaft of the tibia. 2. Inner tuberosity. 3. Outer tuberosity. 4. Spinous process. 5. Tubercle. 6. Internal or subcutaneous surface of the shaft. 7. Lower extremity of the tibia. 8. Internal malleolus. 9. Shaft of the fibula. 10. Its upper extremity. 11. Its lower extremity, the external malleolus. The sharp border between 1 and 6 is the crest of the tibia.

The **shaft** of the tibia presents three surfaces. The *internal* is subcutaneous throughout its lower three-fourths; at the upper part on a line with the tubercle of the tibia it gives attachment to the tendons of the sartorius, gracilis, and semi-tendinosus muscles. The *external* is concave, and marked by a sharp ridge, for the insertion of the interosseous membrane; and the *posterior* is grooved for the attachment of muscles. Near the upper extremity of the posterior surface is an oblique ridge, the *oblique line*, for the attachment of the soleus muscle and fascia of the popliteus muscle; and immediately below the oblique line, the nutrient canal, which is directed downwards.

The **inferior extremity** of the bone is somewhat quadrilateral, and prolonged on its inner side into a large process, the *internal malleolus.* Behind the internal malleolus is a broad and shallow groove for lodging the tendons of the tibialis posticus and flexor longus digitorum; and farther outwards another groove for the tendon of the flexor longus pollicis. At the outer side the surface is concave and trian-

gular, rough above for the attachment of the interosseous ligament; and smooth below, to articulate with the fibula. On the extremity of the bone is a triangular smooth surface for articulation with the astragalus.

Development.—By *three* centres; one for the shaft, and one for each extremity. Ossification commences in the tibia, immediately after the femur; the centre for the head of the bone appears soon after birth, and that for the lower extremity during the second year; the latter is the first to join the diaphysis. The lower epiphysis joins the shaft about the twentieth year, and the bone is completed by the union of the upper epiphysis about the twenty-fifth year. Two occasional centres are sometimes found in the tibia, one for the tubercle, the other for the internal malleolus.

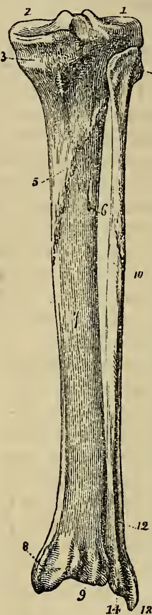


Fig. 143.—Tibia and fibula of the right leg articulated and seen from behind. 1. Articular depression for the external condyle of the femur. 2. Articular depression for the internal condyle; the prominence between the two is the spinous process. 3. Fossa and groove for the insertion of the tendon of the semi-membranosus. 4. Popliteal plane, for the support of the popliteus. 5. Oblique line. 6. Nutrient foramen. 7. Surface of the shaft on which the flexor longus digitorum rests. 8. Broad groove on the back part of the inner malleolus, for the tendons of the flexor longus digitorum and tibialis posticus. 9. Groove for the tendon of the flexor longus pollicis. 10. Shaft of the fibula. The flexor longus pollicis lies on this surface of the bone; its superior limit being marked by the oblique line immediately above the figure. 11. Styloid processes on the head of the fibula for the attachment of the tendon of the biceps. 12. Subcutaneous surface of the lower part of the shaft of the fibula. 13. External malleolus formed by the lower extremity of the fibula. 14. Groove on the posterior part of the external malleolus for the tendons of the peronei muscles.

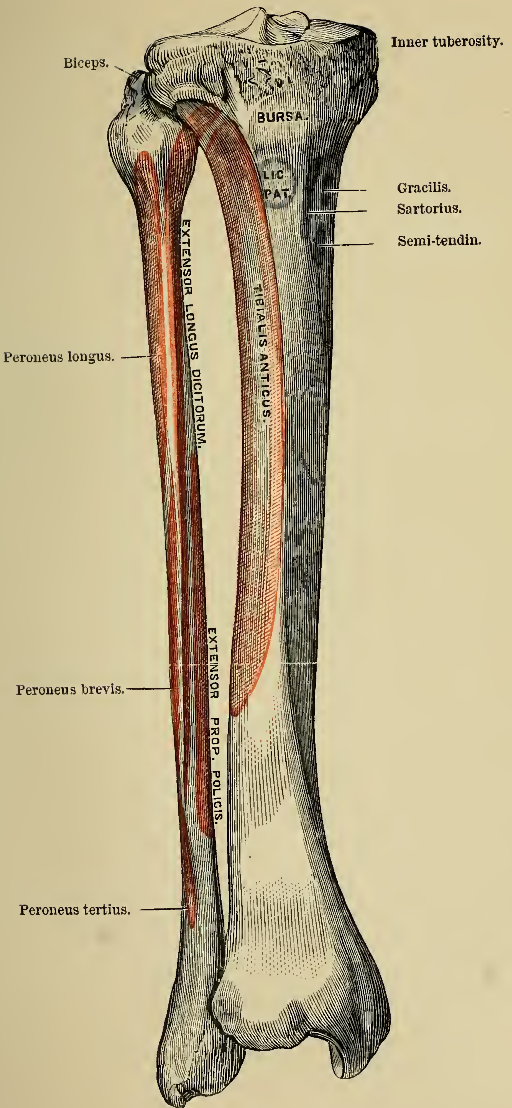
Articulations.—With *three* bones: femur, fibula, and astragalus.

Attachment of Muscles.—To *ten:* by the *internal tuberosity* to the semi-membranosus; by the *external tuberosity*, tibialis anticus and extensor longus digitorum; by the *tubercle*, ligamentum patellæ; by the *external surface* of the shaft, tibialis anticus; by the *posterior surface*, popliteus, soleus, flexor longus digitorum, and tibialis posticus; and by the *internal surface* to the sartorius, gracilis, and semi-tendinosus.

FIBULA.

The fibula (περόνη, a brooch, from its resemblance, in conjunction with the tibia, to the pin of an ancient brooch) is the outer and smaller bone of the leg; it is long and slender in figure, prismoid in shape, and, like other long bones, divisible into a shaft and two extremities.

PLATE 17.


Inner tuberosity.
Biceps.
BURSA.
LIC.
PAT.
Gracilis.
Sartorius.
Semi-tendin.
EXTENSOR LONGUS DICITORUM.
TIBIALIS ANTICUS.
Peroneus longus.
EXTENSOR PROP. POLICIS.
Peroneus brevis.
Peroneus tertius.

The **upper extremity** or head is thick and large, and depressed at the upper part by a concave surface, which articulates with the external tuberosity of the tibia. Externally to this surface is a thick and rough prominence for the attachment of the external lateral ligament of the knee-joint, terminated behind by a styloid process for the insertion of the tendon of the biceps.

The **lower extremity** is flattened from without inwards, and prolonged downwards beyond the articular surface of the tibia, forming the *external malleolus.* Its external side presents a rough and triangular surface, which is subcutaneous. On the internal surface is a smooth triangular facet to articulate with the astragalus, and a rough depression for the insertion of the interosseous ligament. Behind the articular surface and between it and the tip of the malleolus is a deep fossa which lodges the posterior slip of the external lateral ligament. The *anterior border* is thin and sharp, the *posterior* broad and grooved for the tendons of the peronei muscles.

To place the bone in its proper position, and ascertain to which leg it belongs, let the inferior or flattened extremity be directed downwards, and the fossa for the external lateral ligament backwards ; the triangular subcutaneous surface will then point to the side corresponding with the limb of which the bone is part.

The **shaft** of the fibula is prismoid, and presents three surfaces ; external, internal, and posterior ; and three borders. The *external surface* is the broadest of the three ; it commences on the anterior part of the bone above, and curves around it so as to terminate on its posterior side below. This surface is completely occupied by the two peronei muscles. The *internal surface* commences on the side of the superior articular surface, and terminates below by narrowing to a ridge which is continuous with the anterior border of the malleolus. It is marked along its middle by the *interosseous ridge*, which is lost above and below in the inner border of the bone, and which gives attachment to the interosseous membrane. The *posterior surface* is twisted like the external ; it commences above on the posterior side of the bone, and terminates below on its internal side ; at about the middle of this surface is the *nutrient foramen*, which is directed downwards.

The *internal border* commences superiorly in common with the interosseous ridge, and bifurcates inferiorly into two lines, which bound the triangular subcutaneous surface of the external malleolus. The *external border* begins at the base of the styloid process of the head, and winds around the bone, following the direction of the corresponding surface. The *posterior border*, sharp and prominent, is lost inferiorly in the interosseous ridge.

Development.—By *three* centres ; one for the shaft, and one for each extremity. Ossification commences in the shaft soon after its appearance in the tibia ; at birth the extremities are cartilaginous, an osseous deposit taking place in the inferior epiphysis during the second year, and in the superior during the fourth or fifth. The

inferior epiphysis is the first to become united with the diaphysis, but the bone is not completed until nearly the twenty-fifth year. The epiphyses of all the long bones except the fibula unite with the diaphysis in the reverse order of their appearance; but in the fibula, the lower epiphysis, which is the first to appear, is also the first to join the shaft.

Articulations.—With the tibia and astragalus.

Attachment of Muscles.—To *ten:* by the *head*, to the tendon of the biceps and soleus; by the *shaft*, its *external* surface, peroneus longus and brevis; *internal* surface, extensor longus digitorum, extensor proprius pollicis, peroneus tertius, and tibialis posticus; by the *posterior* surface, popliteus and flexor longus pollicis.

TARSUS.

The bones of the tarsus are *seven* in number, viz., astragalus, os calcis, scaphoid, internal, middle, and external cuneiform, and cuboid.

ASTRAGALUS.

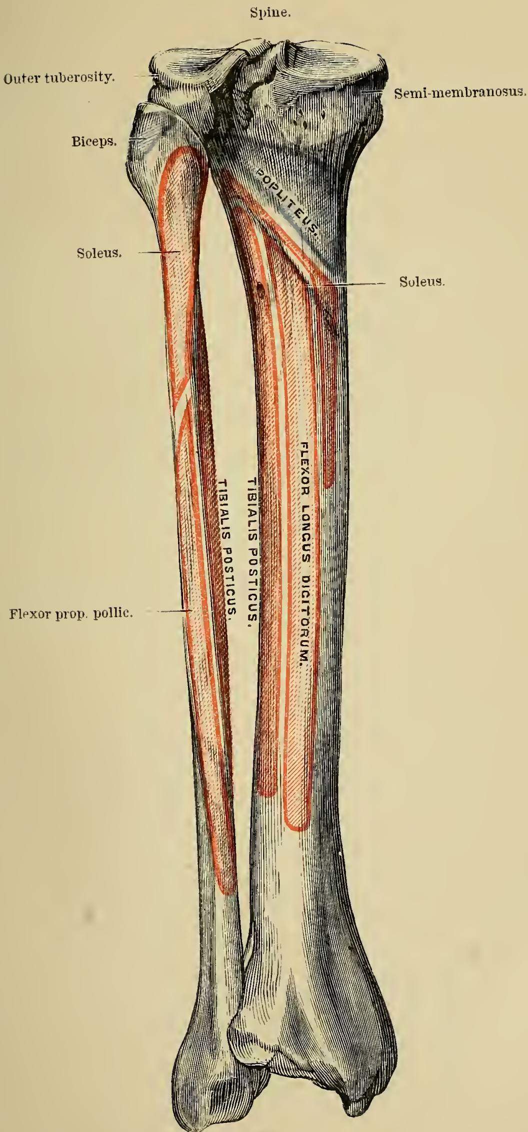
The astragalus (os tali) may be recognised by its rounded head, a broad articular facet on its convex surface, and two articular facets, separated by a deep groove, on its concave surface.

The bone is divisible into a superior and inferior surface, an external and internal border, and an anterior and posterior extremity. The *superior surface* is convex, and presents a large quadrilateral and smooth facet, somewhat broader in front than behind, to articulate with the tibia. The *inferior surface* is concave, and divided by a deep and rough groove (sulcus tali), which lodges a strong interosseous ligament, into two facets—the posterior large and quadrangular, the anterior smaller and elliptic—which articulate with the os calcis. The *internal border*, flat and uneven, is marked by a pyriform articular surface, limited to the upper half of this border, for the inner malleolus. The *external* presents a large triangular articular facet, extending the whole depth of the border, for the external malleolus, and is rough and concave in front. The *anterior extremity* presents a rounded head, encircled by a constriction somewhat resembling a neck; the *posterior extremity* is narrow, and marked by a deep groove for the tendon of the flexor longus pollicis.

Recognition.—Hold the astragalus with the broad articular surface upwards, and rounded head forwards; the large triangular lateral articular surface will point to the side to which the bone belongs.

Articulations.—With *four* bones: tibia, fibula, os calcis, and scaphoid.

PLATE 18.



Spine.
Outer tuberosity.
Semi-membranosus.
Biceps.
POPLITEUS.
Soleus.
Soleus.
FLEXOR LONGUS DIGITORUM.
TIBIALIS POSTICUS.
TIBIALIS POSTICUS.
Flexor prop. pollic.

OS CALCIS.

This bone may be known by its large size and oblong figure, by the massive portion which forms the heel, and by two articular surfaces, separated by a broad groove, upon its upper side.

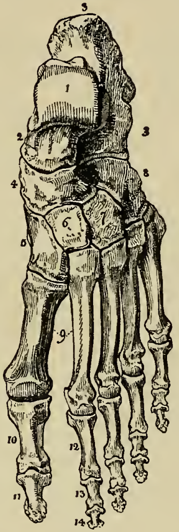


FIG. 144. — Dorsal surface of the left foot. 1. Astragalus; its superior quadrilateral articular surface. 2. Anterior extremity of the astragalus, which articulates with (4) the scaphoid bone. 3, 3. Os calcis. 4. Scaphoid bone. 5. Internal cuneiform bone. 6. Middle cuneiform bone. 7. External cuneiform bone. 8. Cuboid bone. 9. Metatarsal bones of the first and second toes. 10. First phalanx of the great toe. 11. Second phalanx of the great toe. 12. First phalanx of the second toe. 13. Second phalanx. 14. Third phalanx.

The os calcis is divisible into four surfaces, superior, inferior, external, and internal; and two extremities, anterior and posterior. The *superior surface* is convex behind and irregularly concave in front, where it presents two and sometimes three articular facets, divided by a broad and shallow groove (sulcus calcanei), for the interosseous ligament. The *inferior surface* is convex and rough, and bounded posteriorly by the two inferior tuberosities, of which the internal is broad and large, the external smaller and prominent. The *external surface* is convex and subcutaneous, and marked towards its anterior third by two grooves, often separated by a tubercle, for the tendons of the peroneus longus and brevis. The *internal surface* is concave and grooved for the tendons and vessels which pass into the sole of the foot. At the anterior extremity of this surface is a projecting process (sustentaculum tali), which supports the anterior articulating surface of the astragalus, and serves as a pulley for the tendon of the flexor longus pollicis.

At the *anterior extremity* of the bone is a flat articular surface, surmounted by a rough prominence, which affords one of the guides to the surgeon in the performance of Chopart's operation. The *posterior extremity* is prominent and convex, and constitutes the *posterior tuberosity;* it is smooth for the upper half of its extent, where it corresponds with a bursa; and rough below, for the insertion of the tendo Achillis; the lower part of this surface is bounded by the two inferior tuberosities.

Articulations.—With *two* bones: astragalus and cuboid. In their articulated state a large oblique canal is situated between the astragalus and calcaneum, being formed by the apposition of the two grooves, sulcus tali and sulcus calcanei. This canal is called the *sinus tarsi*, and serves to lodge a strong interosseous ligament which ties the two bones together.

Attachment of Muscles.—To *eight:* by the *posterior tuberosity*, to the tendo Achillis and plantaris; by the *inferior tuberosities* and under surface, abductor pollicis, abductor minimi digiti, flexor brevis digitorum, flexor accessorius, and plantar fascia; by the *external surface*, extensor brevis digitorum; and by the *sustentaculum tali*, a few fibres of the tibialis posticus.

SCAPHOID.

This bone may be distinguished by its boat-like figure, concave on one side, and convex with three facets on the other. It presents for examination an anterior and posterior surface, superior and inferior border, and two extremities, one broad, the other pointed and thick. The *anterior surface* is convex, and divided into three facets to articulate with the three cuneiform bones; the *posterior* is concave to articulate with the rounded head of the astragalus. The *superior border* is convex and rough, and the *inferior* somewhat concave and uneven. The *external extremity* is broad and rough; the *internal* pointed and prominent, forming a tuberosity which gives attachment to part of the tendon of the tibialis posticus. The external extremity sometimes presents a facet of articulation with the cuboid.

Recognition.—If the bone be held so that the convex surface with three facets look forwards, and the convex border upwards, the broad extremity will point to the side corresponding with the foot to which the bone belongs.

Articulations.—With *four* bones: astragalus and three cuneiform, sometimes also with the cuboid.

Attachment of Muscles.—To the tendon of the tibialis posticus.

INTERNAL CUNEIFORM.

The internal cuneiform may be known by its irregular wedge shape, and by being larger than the two other bones which bear the same name. It presents for examination a convex and a concave surface, a long and a short articular border, and a small and a large extremity.

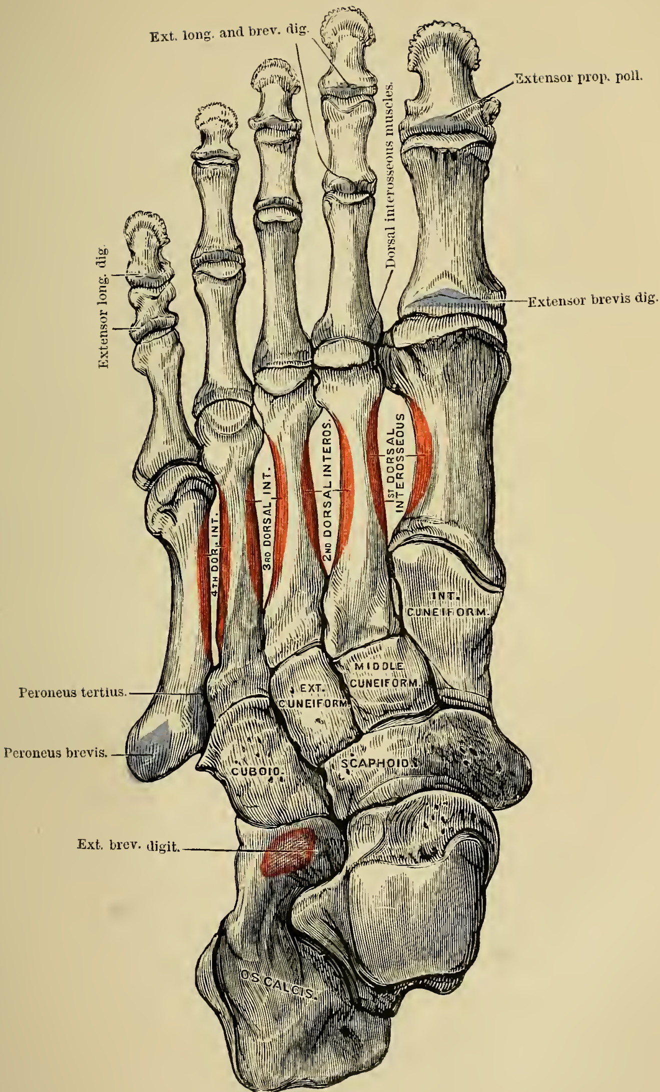
The *convex surface* is internal and free, and assists in forming the inner border of the foot; the *concave* is external, and in apposition with the middle cuneiform and second metatarsal bone; the *long border* articulates with the metatarsal bone of the great toe, the *short border* with the scaphoid bone. The small extremity (edge) is sharp; the larger extremity (base) rounded into a broad tuberosity.

Recognition.—Place the bone so that the small extremity may look upwards and the long articular border forwards, the concave surface will point to the side corresponding with the foot to which it belongs.

Articulations.—With *four* bones: scaphoid, middle cuneiform, and first two metatarsal bones.

Attachment of Muscles.—To the tibialis anticus and posticus.

PLATE 19.



Ext. long. and brev. dig.
Extensor prop. poll.
Dorsal interosseous muscles.
Extensor long. dig.
Extensor brevis dig.
1ST DORSAL INTEROSSEOUS
2ND DORSAL INTEROS.
3RD DORSAL INT.
4TH DOR. INT.
INT. CUNEIFORM.
MIDDLE CUNEIFORM.
EXT. CUNEIFORM.
Peroneus tertius.
Peroneus brevis.
CUBOID.
SCAPHOID.
Ext. brev. digit.
OS CALCIS.

MIDDLE CUNEIFORM.

The middle cuneiform is the smallest of the three; it is wedge-shaped, the broad extremity being placed upwards, the sharp end downwards in the foot. It presents for examination four articular surfaces and two extremities. The *anterior* and *posterior surfaces* have nothing worthy of remark, excepting that the former is narrower than the latter. The *internal lateral* surface has a long articular facet, extending along its upper and posterior margins for the internal cuneiform; the *external* has an articular facet limited to the posterior border for the external cuneiform bone.

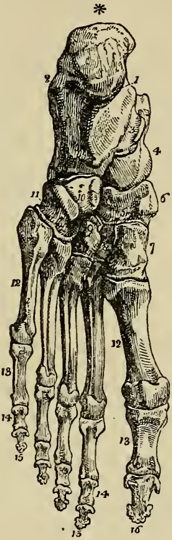


FIG. 145.—Sole of the left foot. 1. Inner tuberosity of the os calcis. 2. Outer tuberosity. * Posterior tuberosity. 3. Groove for the tendon of the flexor longus pollicis; this figure indicates also the sustentaculum tali, upon which it is placed. 4. Rounded head of the astragalus. 5. Scaphoid bone. 6. Its tuberosity. 7. Internal cuneiform bone; its broad extremity. 8. Middle cuneiform bone. 9. External cuneiform bone. 10, 11. Cuboid bone. 11. Groove for the tendon of the peroneus longus; the prominence between this groove and figure 10 is the tuberosity of the bone. 12, 12. Metatarsal bones. 13, 13. First phalanges. 14, 14. Second phalanges of the four lesser toes. 15, 15. Third or ungual phalanges of the four lesser toes. 16. Last phalanx of the great toe.

Recognition.—If the bone be held so that the flat dorsal surface look upwards, its broadest edge being towards the holder, the articular surface, limited to the posterior border, will point to the side to which the bone belongs.

Articulations.—With *four* bones: scaphoid, internal and external cuneiform, and second metatarsal bone.

EXTERNAL CUNEIFORM.

The external cuneiform is intermediate in size between the two preceding, and placed, like the middle, with the broad end upwards, and sharp extremity downwards. It presents for examination four surfaces, and a superior and inferior extremity. The *anterior surface* is wedge-shaped and articular throughout its entire depth, for articulation with the third metatarsal. The *posterior surface*, also wedge-shaped, is articular only in its upper two-thirds, the lower part being rough for the attachment of ligaments. The *external surface* presents posteriorly a large smooth oval articular surface for the cuboid bone, and anteriorly at its upper angle a small facet for the base of the fourth metatarsal. The *internal surface* also

has two facets separated by a rough depression, one along the posterior margin for the middle cuneiform, and the other at the upper and anterior angle of the bone for the base of the second metatarsal. The *upper extremity* is flat, of an oblong square form, and bevelled posteriorly, at the expense of the outer surface, into a sharp edge; the *lower extremity* forms a rounded ridge which serves for the attachment of the tibialis posticus and part of the flexor brevis pollicis.

Recognition.—Hold the bone with the flat dorsal surface upwards and the narrower wedge-shaped articular surface directed backwards; the large oval articular facet for the cuboid will then point to the side to which the bone belongs.

Articulations.—With *six* bones: scaphoid, middle cuneiform, cuboid, and second, third, and fourth metatarsal bones.

Attachment of Muscles.—To the flexor brevis pollicis.

CUBOID.

The cuboid bone is irregularly cuboid in shape, and marked on its under surface by a deep groove for the tendon of the peroneus longus muscle. It presents for examination six surfaces, three articular and three non-articular. The *non-articular* surfaces are—*superior*, which is slightly convex, and assists in forming the dorsum of the foot; *inferior*, marked by a prominent ridge, the *tuberosity*, and a deep groove for the tendon of the peroneus longus; and *external*, the smallest of the whole, and deeply notched by the commencement of the peroneal groove. The *articular surfaces* are—*posterior*, of large size, and concavo-convex, to articulate with the os calcis; *anterior*, of smaller size, divided by a slight ridge into two facets, for the fourth and fifth metatarsal bones; and *internal*, a small oval articular facet, upon a large and quadrangular surface, for the external cuneiform bone.

Recognition.—If the bone be held so that the plantar surface, with the peroneal groove, look downwards, and the largest articular surface backwards, the small non-articular surface, marked by the deep notch, will point to the side to which the bone belongs.

Articulations.—With *four* bones: os calcis, external cuneiform, fourth and fifth metatarsal bone, and sometimes the scaphoid.

Attachment of Muscles.—To *two:* flexor brevis pollicis, and adductor pollicis.

Upon a consideration of the articulations of the tarsus it will be observed, that each bone articulates with four adjoining bones, with the exception of the calcaneum which articulates with two, and the external cuneiform with six.

Development.—By a single centre for each bone, with the exception of the os calcis, which has an epiphysis for its posterior tuberosity. The centres appear in the following order: calcanean, sixth month; astragalan, seventh month; cuboid, ninth month; external

cuneiform, end of the first year; internal cuneiform, during the third year; middle cuneiform and scaphoid, during the fourth year. The epiphysis of the calcaneum appears at the ninth year, and is united with the diaphysis at about the fifteenth.

METATARSAL BONES.

These bones, *five* in number, are long bones, and divisible therefore into a shaft and two extremities. The shaft is prismoid, and compressed from side to side; the posterior extremity, or base, is wedge-shaped, to articulate with the tarsal bones, and with each other; the anterior extremity presents a rounded head, circumscribed by a neck, to articulate with the first row of the phalanges.

Peculiar Metatarsal Bones.—The *first* is shorter and larger than the rest, and forms part of the inner border of the foot; its posterior extremity has no lateral facet, but presents a large kidney-shaped surface at its base, and an oval rough prominence beneath for the insertion of the tendon of the peroneus longus. The head of the bone has, on its plantar surface, two grooved facets, for sesamoid bones. To find the side to which the bone belongs, hold it with the base towards you and the convex surface upwards, the concavity of the kidney-shaped surface will then point to the appropriate side.

The *second* is the longest and largest of the remaining metatarsal bones; it presents at its base an articular facet for the middle cuneiform bone, and has on its outer lateral surface four facets, two for the outer cuneiform and two for the third metatarsal. On its inner surface it has only one facet, for the internal cuneiform. If the bone be held with its head directed forwards and the convex surface of the shaft upwards, the four lateral facets will point to the side to which it belongs.

The *third* may be known by two facets on the inner side of its base, corresponding with the second, and one on the outer side for the third metatarsal. It may be distinguished also by its smaller size. When held in the usual position, the side with the single facet will indicate the foot to which the bone belongs.

The *fourth* may be distinguished by its smaller size, and by having a single articular surface on each side of the base. When held with the base backwards and dorsal surface upwards, the most prominent angle at the base will point to the foot to which the bone belongs.

The *fifth* is recognised by its broad base, and by the large tuberosity at its outer side.

Development.—Each bone by *two* centres; one for the body and one for the digital extremity in the four outer metatarsal bones; and one for the body, the other for the base, in the metatarsal bone of the great toe. Ossification appears in these bones at the same time as in the vertebræ; the epiphyses appear in the heads of the metatarsals of the four outer toes about the third year, and in the

base of that of the great toe in the fifth year, consolidation being effected at eighteen.

Articulations.—With the tarsal bones by one extremity, and first row of phalanges by the other. The number of tarsal bones with which each metatarsal articulates from within outwards, is the same as between the bones of the metacarpus and carpus, one for the first, three for the second, one for the third, two for the fourth, and one for the fifth, forming the cipher 13121.

Attachment of Muscles.—To *fourteen:* to the first, peroneus longus and first dorsal interosseous; to the second, two dorsal interossei and transversus pedis; to the third, two dorsal and one plantar interosseous, adductor pollicis and transversus pedis; to the fourth, two dorsal and one plantar interosseous, adductor pollicis and transversus pedis; to the fifth, one dorsal and one plantar interosseous, peroneus brevis, peroneus tertius, abductor minimi digiti, flexor brevis minimi digiti, and transversus pedis.

PHALANGES.

There are two phalanges in the great toe and three in the other toes, as in the hand. They are long bones, divisible into a central portion and extremities.

The phalanges of the first row are convex above, concave on the under surface, and compressed from side to side. The posterior extremity has a single concave articular surface, for the head of the metatarsal bone; the anterior extremity, a pulley-like surface, for the second phalanx.

The *second phalanges* are short and diminutive, but somewhat broader than those of the first row.

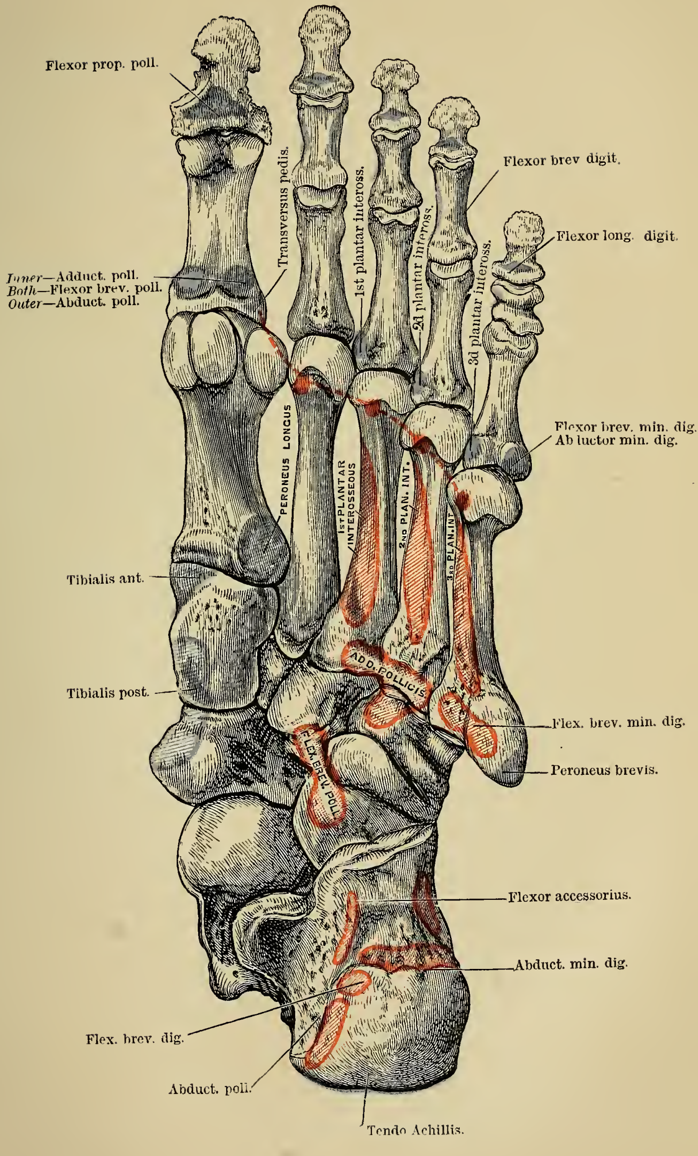
The *third* or *ungual phalanges*, including the second phalanx of the great toe, are flattened from above downwards, spread out laterally at the base to articulate with the second row, and at the opposite extremity to support the nail and the rounded extremity of the toe.

Development.—By *two* centres; one for the body and one for the metatarsal extremity. Ossification commences in these bones after the metatarsus, appearing firstly in the last phalanges, then in the first, and lastly in the middle row. The centres for the epiphyses appear during the fourth year for the first row, and the sixth year for the other two rows. The bones are completed at eighteen.

Articulations.—The first row with the metatarsal bones and second phalanges; the second, of the great toe, with the first phalanx; of the other toes, with the first and third phalanges; the third, with the second row.

Attachment of Muscles.—To *twenty-three:* to the *first phalanges; great toe*, innermost tendon of the extensor brevis digitorum, abductor pollicis, adductor pollicis, flexor brevis pollicis, and transversus pedis; *second toe*, first and second dorsal interosseous and lumbri-

PLATE 20.


Flexor prop. poll.
Transversus pedis.
1st plantar inteross.
2d plantar inteross.
3d plantar inteross.
Flexor brev digit.
Flexor long. digit.
Inner—Adduct. poll.
Both—Flexor brev. poll.
Outer—Abduct. poll.
PERONEUS LONGUS
1ST PLANTAR INTEROSSEOUS
2ND PLAN. INT.
3RD PLAN. INT
Flexor brev. min. dig.
Ab luctor min. dig.
Tibialis ant.
ADD. POLLICIS
Tibialis post.
Flex. brev. min. dig.
FLEX. BREV. POLL
Peroneus brevis.
Flexor accessorius.
Abduct. min. dig.
Flex. brev. dig.
Abduct. poll.
Tendo Achillis.

calis; *third toe*, third dorsal and first plantar interosseous and lumbricalis; *fourth toe*, fourth dorsal and second plantar interosseous and lumbricalis; *fifth toe*, third plantar interosseous, abductor minimi digiti, flexor brevis minimi digiti and lumbricalis. *Second phalanges: great toe*, extensor longus pollicis, and flexor longus pollicis; *other toes*, one slip of the common tendon of the extensor longus and extensor brevis digitorum, and flexor brevis digitorum. *Third phalanges:* two slips of the common tendon of the extensor longus and extensor brevis digitorum, and the flexor longus digitorum.

SESAMOID BONES.

These are small osseous masses, developed in those tendons which exert a certain degree of force upon the surface over which they glide, or where, by continued pressure and friction, the tendon would become a source of irritation to neighbouring parts, as to joints. The best example of a sesamoid bone is the patella, developed in the common tendon of the quadriceps extensor, and resting against the front of the knee-joint. Besides the patella, there are four pairs of sesamoid bones constantly found, two on the metacarpo-phalangeal articulation of each thumb, and existing in the tendons of insertion of the flexor brevis pollicis, and two on the corresponding joint in the foot, in the tendons of the muscles inserted into the base of the first phalanx. In addition to these there is often a sesamoid bone on the metacarpo-phalangeal joint of the little finger; and on the corresponding joint in the foot, in the tendons inserted into the base of the first phalanx; there is one also in the tendon of the peroneus longus muscle, where it glides through the groove in the cuboid bone; sometimes in the tendons, as they wind around the inner and outer malleolus; in the psoas and iliacus, where they glide over the body of the os pubis; and in the external head of the gastrocnemius.

The **bones of the tympanum**, as they belong to the apparatus of hearing, will be described with the anatomy of the ear.

PART III.

ARTHROLOGY.

Articulations or joints are the means by which the bones of the skeleton are united together, the same terms being also applied to the union between cartilages when these are adapted for movement on each other, as for instance in the larynx. The connections between the bones may take place simply by the intervention of a small quantity of connective tissue, and the union be so close as to render movement impossible, forming an immovable joint, or **Synarthrosis**; or the bones may be widely separated, and the substance lying between them and connecting them together may be so yielding as to admit of a limited degree of movement in several directions, forming a yielding joint, or **Amphi-arthrosis.** In all the articulations of the limbs, however, we find a more elaborate and perfect arrangement admitting of much freer motion, constituting a movable joint, or **Diarthrosis.** In the latter the expanded ends of the bones are coated by a thin layer of cartilage, are connected together by bands of fibrous tissue called *ligaments*, and are lubricated by the fluid secreted by a synovial membrane which lines the inner surface of the ligaments; in many joints, also, a disc of fibro-cartilage is interposed between the articular surfaces, and the cavity divided into two, the advantages of a double joint being thus secured.

The structures entering into the composition of a joint are bone, cartilage, areolar and adipose tissue, elastic tissue, fibrous tissue, and synovial membrane; the microscopic anatomy of these has been fully described in Part I. of this work, but it remains to point out their peculiar arrangement in the construction of joints.

The *articular ends of long bones* are expanded and rendered either concave or convex, so as to fit each other; they are formed of cancellous tissue with an outer thin coating of dense bone. In some places the bones are produced into projecting processes which overhang the joint, affording protection against external injury, as well as giving greater leverage to the muscles; this arangement may be

noticed in the elbow, ankle, and wrist joints. The *cartilage* found in joints is of two kinds, hyaline and fibro-cartilage. The former is known as true articular cartilage, or cartilage of incrustation; it coats the articular surfaces of the bones, and is generally so arranged as to increase the depth of articular cavities and the prominence of articular convexities, being in the one case thickest at its edges, and in the other in the middle. Fibro-cartilage is in amphi-arthrodial joints the connecting medium binding the bones together; in diarthrodial joints it forms encircling bands which deepen the articular cavities, or it occurs as concave discs (interarticular fibro-cartilages) which divide the joint into two parts, each part having its own synovial membrane. *Areolar* and *adipose tissue* are used for filling up the interstices in and around joints, so as to ensure the perfect adaptation of the articular surfaces to each other; in joints (such as the knee) which received little protection from the surrounding muscles, the amount of fat found among the ligaments and beneath the superficial fascia is relatively very large. The *ligaments* which connect the bones together are for the most part formed of strong bands of white fibrous tissue, but in some few a slight admixture of yellow fibres may be observed, and those connecting the laminæ of the vertebræ (ligamenta subflava) are entirely formed of yellow or elastic tissue. In the joints possessing the freest movement the ligaments form a fibrous envelope which entirely surrounds and encloses the articular surfaces—these are called *capsular ligaments;* in those enjoying the next degree of mobility the ligaments exist as flattened bands arranged in front, behind, and at the sides of the articulation. Some few joints have ligamentous bands in their interior; examples of these are the ligamentum teres of the hip and crucial ligaments of the knee; they are enclosed in a tube formed of synovial membrane. The *synovial membrane* lines the whole of the interior of the joint, except where the articular cartilage is interposed; it is smooth and glistening on the inner surface, rough externally where it becomes attached to the bones and ligaments; it often forms folds, which project into the interior of the joint and contain masses of fat with loops of capillary vessels.

Besides the structures which form the joints, others also contribute to keep the articular ends of the bones in place, and to ensure due and smooth movement; of these the most important are the muscles and bursæ. The muscles not only act as the agents of motion, but are of essential service in maintaining the structures of the joint in their proper relative position, supporting the ligaments by their tonic contraction, and in some instances acting directly on the synovial membrane so as to prevent its becoming squeezed between the ends of the bones. In the shoulder-joint the tendon of a muscle passes through the synovial cavity, and in both that joint and the knee the tendons of certain muscles take the place of ligaments and are coated on their interior by synovial membrane.

Bursæ mucosæ are closed synovial sacs, the structure of which has

been described on a previous page. Some of them lie between the tendons of muscles and the ligaments of joints, and in this position often communicate with the cavities of those joints; this being especially apt to occur with the bursa which lies between the capsule of the hip-joint and the united tendons of the psoas and iliacus. Bursæ occur (1) between tendons and bones, (2) between tendons and ligaments, (3) between superficial bony prominences and the fasciæ beneath the skin, (4) between contiguous tendons, and (5) between neighbouring bones. They are very numerous, about 140 being found in the human body. *Superficial bursæ* are constantly found in the following positions:—In the head and neck they occur on each angle of the lower jaw, beneath the symphysis of the jaw, and on the salient angle of the thyroid cartilage. In the upper extremity, over the acromion process, on the external and internal condyles of the humerus, on the back of the olecranon, the styloid processes of the radius and ulna, and the dorsal and palmar surfaces of the metacarpo-phalangeal joints. In the lower extremity they are found on the anterior superior spine of the ilium, over the great trochanter, on the tuberosity of the ischium, the lower half and the upper and outer angle of the patella, on the outer and inner condyles of the femur, the outer and inner tuberosities of the tibia, the head of the fibula, the outer and inner malleoli, the posterior and inner face of the os calcis, and the dorsal surface of the articulations of the toes. The *deep bursæ* lie between the tendons of muscles, or between the tendons and joints; these are even more numerous than the superficial ones, so that only a few of the more important will be mentioned here. These are the bursa beneath the deltoid, that between the tendon of the psoas and capsule of the hip-joint, one beneath the tendon of insertion of the triceps, one beneath the ligamentum patellæ, one between the gluteus maximus and vastus internus, one beneath the tendon of insertion of the biceps of the arm, and one between the tendon of insertion of the semi-membranosus and the inner head of the gastrocnemius. Besides these normal bursæ, other accidental or pathological ones are formed wherever there is great pressure, as for instance on the parts of the foot which come in contact with the ground in club-foot, and on the ends of stumps after amputation.

TABLE OF ARTICULATIONS.

I. SYNARTHROSIS.

	Example.
1. **Suture**	Tabular bones of skull.
2. **Harmonia**	Union of bones of face.
3. **Schindylesis** . . .	Vomer with rostrum of sphenoid.
4. **Gomphosis**	Teeth with alveolar processes.

II. AMPHI-ARTHROSIS.

1. Complete union by fibro-cartilage	Intervertebral substance.
2. Partial synovial cavity . .	Symphysis pubis, and sacro-iliac joint.

III. DIARTHROSIS.

1. **Arthrodia**	Sterno- and acromio-clavicular articulations.
2. **Ginglymus**	Ankle, elbow, knee.
3. **Trochoides**	Odontoid process with atlas, and upper radio-ulnar joint.
4. **Enarthrosis** . . .	Hip, shoulder.

SYNARTHROSIS (σὺν, ἄρθρωσις, articulation) is expressive of the fixed form of joint in which the bones are immovably connected with each other. The kinds of synarthrosis are four in number : *Sutura*, *Harmonia*, *Schindylesis*, *Gomphosis*. The characters of the three first have been sufficiently explained in the preceding Part, p. 104. It is here only necessary to state that in the construction of sutures, the substance of the bones is not in immediate contact, but separated by a layer of membrane, which is continuous externally with the pericranium and internally with the dura mater. It is the latter connection which gives rise to the resistance experienced in tearing the calvarium from the dura mater. The fourth, Gomphosis (γόμφος, a nail), is expressive of the insertion of one bone into another, as a nail is fixed into a board ; this is illustrated in the articulation of the teeth with the alveoli of the maxillary bones.

AMPHI-ARTHROSIS (ἀμφὶ, both, ἄρθρωσις) is a joint intermediate in aptitude for motion between the immovable synarthrosis and the movable diarthrosis. Two forms of it are described, namely, those where the union takes place entirely by means of fibro-cartilage, without any joint cavity, and those where some part of the joint is formed by surfaces coated with articular cartilage, between which there is a small synovial cavity. Examples of the first are seen in the union between the bodies of the vertebræ, the sacrum with the coccyx, and the pieces of the sternum ; and of the second, the sacro-iliac and pubic symphyses (σὺν φυεὶν, to grow together).

DIARTHROSIS (διὰ, through, ἄρθρωσις) is the movable articulation which constitutes by far the greater number of the joints of the body. The degree of motion in this class has given rise to a subdivision into four genera : Arthrodia, Ginglymus, Trochoides, and Enarthrosis.

Arthrodia is the movable joint in which the extent of motion is slight and limited, as in the articulations of the clavicle, ribs,

articular processes of the vertebræ, axis with the atlas, radius with the ulna, fibula with the tibia, carpal and metacarpal, tarsal and metatarsal bones. It is formed by the apposition of two nearly plane articular surfaces. The movement is very limited, but by bringing together a number of small bones articulated in this way, great pliability is obtained, as may be observed in the carpus.

Ginglymus (γιγγλυμὸς, a hinge), or hinge-joint, is the movement of bones upon each other in two directions only, viz., forwards and backwards; but the degree of motion may be very considerable. Instances of this form of joint are numerous; they comprehend the elbow, wrist, metacarpo-phalangeal, and phalangeal joints in the upper extremity; the knee, ankle, metatarso-phalangeal, and phalangeal joints in the lower extremity. The articulation of the lower jaw exhibits an example of the combination of this form of joint with the preceding, the joint between the interarticular cartilage and eminentia articularis being arthrodial, and that between the cartilage and the condyle ginglymous.

The form of the ginglymoid joint is somewhat quadrilateral, each of its four sides being provided with a ligament, which is named from its position, *anterior*, *posterior*, *internal lateral*, or *external lateral.* The *lateral ligaments* are thick and strong, and the chief bond of union between the bones. The *anterior* and *posterior* are thin and loose in order to permit the required extent of movement.

Trochoides or **lateral ginglymus** is a form of joint of which there exist only two examples in the human body, namely, the articulation of the anterior arch of the atlas and transverse ligament with the odontoid process of the axis, and the superior radio-ulnar joint. In the first of these a ring composed partly of bone and partly of ligament rotates round a pivot, in the second the rounded bone moves within a ring formed of ligamentous fibres; in both the movement is purely rotatory.

Enarthrosis (ἐν, in, ἄρθρωσις) is the most extensive in its range of motion of all the movable joints. From the manner of connection and form of the bones in this articulation, it is called the ball-and-socket joint. There are two instances in the body, namely, the hip and the shoulder.

We may add to the preceding the carpo-metacarpal articulation of the thumb, although not strictly a ball-and-socket joint, from the great extent of motion which it enjoys, and from the nature of the ligament connecting the bones. As far as the articular surfaces are concerned, it is rather a double than a single ball-and-socket, and the whole of these considerations remove it from the simple arthrodial and ginglymoid groups.

The ball-and-socket joint has a circular form; and, in place of the four distinct ligaments of the ginglymus, is enclosed in a bag of ligamentous membrane, called *capsular ligament.*

MOVEMENTS OF JOINTS.

The motions of joints may be referred to four heads, viz., Gliding, Angular movement, Circumduction, and Rotation.

1. **Gliding** is the simple movement of one articular surface on another, and exists to a greater or less extent in all the joints. In the least movable joints, as in the carpus and tarsus, this is the only motion which is permitted. Gliding is, in certain joints, accompanied by what is known as *coaptation*, that is, the successive application of different parts of an articular surface to its fellow, in the manner of a wheel rolling on the ground.

2. **Angular movement** may be performed in four different directions, either forwards and backwards, as in flexion and extension; or inwards and outwards, constituting adduction and abduction. Flexion and extension are illustrated in the ginglymoid joint, and exist in a large proportion of the joints of the body. Adduction and abduction, conjoined with flexion and extension, are met with complete only in the most movable joints, as the shoulder, hip, and thumb. In the wrist and ankle, adduction and abduction are only partial.

3. **Circumduction** is most strikingly exhibited in the shoulder and hip joints; it consists in the slight degree of motion which takes place between the head of a bone and its articular cavity, while the extremity of the limb is made to describe a large circle on a plane surface. It is also seen, but in a less degree, in the carpo-metacarpal articulation of the thumb, and the metacarpo-phalangeal articulation of the fingers and toes.

4. **Rotation** is the movement of a bone on its own axis, and is illustrated in the hip and shoulder, or better, in the rotation of the cup of the radius against the eminentia capitata of the humerus. Rotation is also observed in the movements of the atlas upon the axis, where the odontoid process serves as a pivot around which the atlas turns.

ARTICULATIONS.

The joints may be arranged, according to a natural division, into those of the trunk, those of the upper extremity, and those of the lower extremity.

LIGAMENTS OF THE TRUNK.

The articulations of the trunk are divisible into eleven groups, namely :—

1. Of the vertebral column.
2. Of the atlas, with the occipital bone.
3. Of the axis, with the occipital bone.
4. Of the atlas, with the axis.

5. Of the lower jaw.
6. Of the ribs, with the vertebræ.
7. Of the costal cartilages, with the sternum, and with each other.
8. Of the ribs, with the costal cartilages.
9. Of the sternum.
10. Of the vertebral column, with the pelvis.
11. Of the pelvis.

1. **ARTICULATION OF THE VERTEBRAL COLUMN.**—The ligaments connecting together the different pieces of the vertebral column, admit of the same arrangement as the vertebræ themselves. Thus the ligaments

Of the **bodies**, are the	Anterior common ligament, Posterior common ligament, Intervertebral substance.
Of the **arches**,	Ligamenta subflava.
Of the **articular processes**,	Capsular ligaments, Synovial membranes.
Of the **spinous processes**,	Inter-spinous, Supra-spinous.
Of the **transverse processes**,	Inter-transverse.

BODIES.—The **anterior common ligament** is a broad and ribbon-like band of ligamentous fibres, extending along the front surface of the vertebral column, from the axis to the sacrum. It is intimately connected with the intervertebral substance, and less closely with the bodies of the vertebræ. In the dorsal region it is thicker than in the cervical and lumbar, and consists of a median and two lateral portions separated from each other by a series of openings for the passage of vessels. The ligament is composed of fibres of various lengths closely interwoven with each other; the *deeper* and shorter crossing the intervertebral substance from one vertebra to the next; the *superficial* and longer fibres crossing three or four vertebræ.

The anterior common ligament is in relation by its *posterior* or *vertebral surface* with the intervertebral substance, bodies of vertebræ, and vessels, principally veins, which separate its central from its lateral portions. By its *anterior* or *visceral surface* it is in relation, in the neck, with the longus colli muscles, pharynx and œsophagus; in the thoracic region, with the aorta, venæ azygos, and

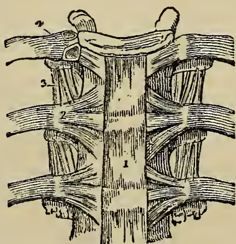


FIG. 146.—Anterior ligament of the vertebræ, and ligaments of the ribs. 1. Anterior common ligament. 2. Anterior costo-vertebral or stellate ligament. 3. Anterior costo-transverse ligament. 4. Interarticular ligament connecting the head of the rib to the intervertebral substance, and separating the two synovial membranes of this articulation.

thoracic duct; in the lumbar region, with the aorta, right renal artery, right lumbar arteries, arteria sacra media, vena cava inferior, left lumbar veins, receptaculum chyli, commencement of the thoracic duct, and crura of the diaphragm, with the fibres of which the ligamentous fibres interlace.

The **posterior common ligament** lies on the posterior surface of the bodies of the vertebræ, and extends from the axis to the sacrum. It is broad opposite the intervertebral substance, to which it is closely adherent; narrow and thick over the bodies of the vertebræ, from which it is separated by the veins of the base of each vertebra; it thus comes to present a festooned or dentate margin. It is composed, like the anterior ligament, of shorter and longer fibres, arranged in a similar manner. It is broader above than below, the reverse of the anterior common ligament, and is thicker in the dorsal than in the cervical or lumbar region. At its upper end it is continuous with the posterior occipito-axial ligament.

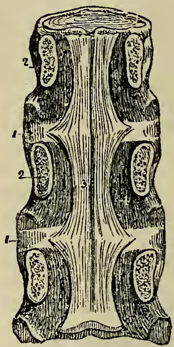


FIG. 147.—A posterior view of the bodies of three dorsal vertebræ, connected by their intervertebral substance, 1, 1. The laminæ (2) have been sawn through near the bodies of the vertebræ, and the arches and processes removed, in order to show (3) the posterior common ligament. Part of one of the openings in the posterior surface of the vertebra, for the transmission of the vena basis vertebræ, is seen at 4, by the side of the narrow and unattached portion of the ligament.

The posterior common ligament is in relation, by its *anterior surface*, with the intervertebral substance, bodies of the vertebræ, and venæ basium vertebrarum; by its *posterior surface*, with the dura mater of the spinal cord, some loose cellular tissue and numerous small veins being interposed.

The **intervertebral substance** (intervertebral ligament) is a lenticular disc of fibro-cartilage, interposed between the bodies of the vertebræ from the axis to the sacrum, and retaining them firmly in connection with each other. The discs vary in thickness in different parts of the column and at different points of the same disc, being thickest in the lumbar region, deepest in front in the cervical and lumbar regions, and behind in the dorsal region; and contribute to the formation of the natural curves of the vertebral column. The aggregate thickness of the intervertebral substance has been estimated at one-fourth that of the entire vertebral column, exclusive of the sacrum and coccyx.

When the intervertebral substance is bisected either horizontally or vertically, it is seen to be composed of a series of layers of fibro-cartilage mixed with fibrous tissue. The central part of each intervertebral disc is much softer than the rest; it has the appearance of pulp, and is so elastic as to rise above the level of the section as soon as its division is completed. Examined from the exterior, the layers

are found to consist of fibres passing obliquely between the two vertebræ, in one layer passing from left to right, in the next from right to left, alternating in each successive layer. Examined microscopically, the central pulp is found to be composed of fine fibrous tissue supporting cells some of which resemble those of cartilage; it is generally regarded as a persistent part of the chorda dorsalis.

ARCHES. — The **ligamenta subflava** are two thin planes of yellow fibrous tissue, situated between the arches of the vertebræ, from the axis to the sacrum. From the imbricated position of the laminæ, they are attached to the posterior surface of the vertebra below, and the anterior surface of the arch of the vertebra above, being separated from each other in the cervical region at the middle line by a slight interspace filled with areolar tissue. In the dorsal and lumbar regions they are continued for a little way on to the roots of the spinous processes, where they unite with the interspinous ligaments and with each other. They counteract, by their elasticity, the efforts of the flexor muscles of the trunk; and, preserving the upright position of the spine, limit the expenditure of muscular force. They are longest in the cervical and thickest in the lumbar region.

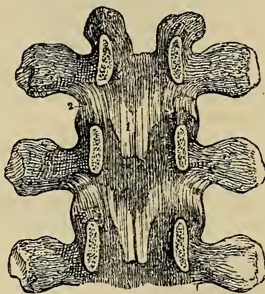


FIG. 148.—Internal view of the arches of three vertebræ. To obtain this view the laminæ have been divided through their pedicles. 1. One of the ligamenta subflava. 2. The capsular ligament of one side.

The ligamenta subflava are continued in the cervical region on to the inner side, and in the dorsal and lumbar regions on to both anterior and inner sides of the articular processes, so as to form part of the capsules of the joints. They are in relation by both surfaces with the meningo-rachidian veins, and, internally, are separated from the dura mater of the spinal cord by those veins and some loose cellular and adipose tissue.

ARTICULAR PROCESSES.—The ligaments of the articular processes of the vertebræ are thin **capsules** of white and yellow fibres which surround and enclose the synovial membrane; the latter being looser in the cervical than in the other regions of the spine.

SPINOUS PROCESSES.—The **interspinous ligaments**, thin and membranous, are extended between the spinous processes in the dorsal and lumbar region; being thickest in the latter. They are in *relation* with the interspinous muscles at each side.

The **supraspinous ligament** (fig. 157) is a strong, fibrous cord, extending from the apex of the spinous process of the last cervical vertebra to the coccyx, and attached to each spinous process in its course. Like the anterior and posterior common ligaments, it is composed of fibres of unequal length, the deeper fibres passing from one vertebra to the next, the superficial fibres extending over several

spinous processes. It is thickest in the lumbar region. The continuation of this ligament upwards to the tuberosity of the occipital bone, constitutes the rudimentary ligamentum nuchæ of man. The latter is strengthened, as in animals, by a thin slip from the spinous process of each cervical vertebra. At its lower termination the supraspinous ligament spreads out to cover the end of the spinal canal, exposed by the deficiency of the laminæ of the lower sacral and coccygeal vertebræ.

TRANSVERSE PROCESSES.—The **intertransverse ligaments**, thin and membranous, are found only between the transverse processes of the lower dorsal vertebræ.

2. **ARTICULATION OF THE ATLAS WITH THE OCCIPITAL BONE.**—The ligaments of this articulation are *seven* in number :—

Two anterior occipito-atlantal,	Lateral occipito-atlantal,
Posterior occipito-atlantal,	Two capsular.

Of the two **anterior ligaments**, one is a *rounded* cord, situated in the middle line, and superficially to the other; it is attached above

FIG. 149.—Anterior view of the ligaments connecting the atlas, axis, and occipital bone. A transverse section has been carried through the base of the skull, dividing the basilar process of the occipital bone and the petrous portion of the temporal bones. 1. Anterior round occipito-atlantal ligament. 2. Anterior broad occipito-atlantal ligament. 3. Commencement of the anterior common ligament. 4. Anterior atlanto-axial ligament, continuous inferiorly with the commencement of the anterior common ligament. 5. One of the atlanto-axial capsular ligaments; that on the opposite side has been removed to show the approximated surfaces of the articular processes (6). 7. One of the occipito-atlantal capsular ligaments. The most external of these fibres constitute the lateral occipito-atlantal ligament.

to the basilar process of the occipital bone; below, to the anterior tubercle of the atlas. The deeper ligament is a *broad* membranous layer, attached above to the margin of the occipital foramen, between the two condyles; and below, to the whole length of the anterior arch of the atlas; it is continuous laterally with the capsular ligaments. It is in relation in front with the recti antici minores, behind with the odontoid ligaments.

The **posterior ligament** is thin and membranous; attached above to the margin of the occipital foramen, between the two condyles; and below, to the posterior arch of the atlas. It is closely adherent to the dura mater, by its inner surface; and forms a ligamentous arch at each side for the passage of the vertebral artery and first cervical nerve. It corresponds in its position to the ligamenta subflava of the other vertebræ, but it has no elastic fibres, being composed entirely of white fibrous tissue. It is in relation posteriorly with the recti postici minores and obliqui superiores.

The **lateral ligaments** are strong fasciculi of ligamentous fibres, attached below to the base of the transverse process of the atlas at each side; and above, to the transverse process of the occipital bone. With the assistance of a ligamentous expansion derived from the vaginal process of the temporal bone, these ligaments form a strong sheath around the vessels and nerves which pass through the carotid and jugular foramina.

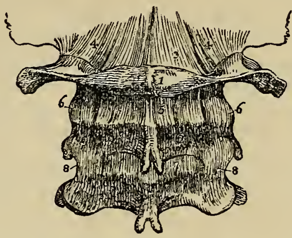


Fig. 150.—Posterior ligaments of the occipito-atlantal and atlanto-axial articulations. 1. Atlas. 2. Axis. 3. Posterior ligament of the occipito-atlantal articulation. 4, 4. Capsular and lateral ligaments of this articulation. 5. Posterior ligament of the atlanto-axial articulation. 6, 6. Its capsular ligaments. 7. The first pair of ligamenta subflava; passing between the axis and third cervical vertebra. 8, 8. Capsular ligaments of those vertebræ.

The **capsular ligaments** are the thin and loose ligamentous capsules which surround the synovial membranes of the articulations between the condyles of the occipital bone and the superior articular processes of the atlas. The ligamentous fibres are most numerous on the anterior and external part of the articulation.

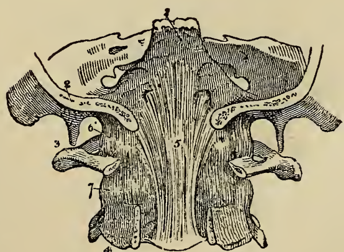
The *movements* taking place between the cranium and atlas are those of flexion and extension, giving rise to the forward nodding of the head. When this motion is increased to any extent, the whole of the cervical region concurs in its production.

3. **ARTICULATION OF THE AXIS WITH THE OCCIPITAL BONE.**—The ligaments of this articulation are *four* in number:—

Occipito-axial, Three odontoid.

The **occipito-axial ligament** (apparatus ligamentosus colli) is a broad and strong band, which covers in the odontoid process and

Fig. 151.—Upper part of the vertebral canal, opened from behind in order to show the occipito-axial ligament. 1. Basilar portion of the sphenoid bone. 2. Section of the occipital bone. 3. Atlas, its posterior arch removed. 4. Axis, posterior arch removed. 5. Occipito-axial ligament, rendered prominent at its middle by the projection of the odontoid process. 6. Lateral and capsular ligament of the occipito-atlantal articulation. 7. Capsular ligament of the articular process of the atlas and axis.



its ligaments. It is attached below to the body of the axis, where it is continuous with the posterior common ligament; superiorly it is

inserted by a broad expansion into the basilar groove of the occipital bone. It is firmly connected opposite the body of the axis with the dura mater, and is sometimes described as consisting of a central and two lateral portions.

The **odontoid ligaments** are two short and thick fasciculi, which pass outwards from the apex of the odontoid process to the sides of the occipital foramen and condyles. A third and smaller fasciculus (ligamentum dentis suspensorium) proceeds from the apex of the odontoid process to the anterior margin of the foramen magnum.

These ligaments serve to limit the extent of rotation of the head, hence they are termed *check* ligaments.

4. **ARTICULATION OF THE ATLAS WITH THE AXIS.** —The ligaments of this articulation are *five* in number :—

Anterior atlanto-axial,	Two capsular,
Posterior atlanto-axial,	Transverse.

The **anterior ligament** consists of ligamentous fibres which pass from the anterior tubercle and arch of the atlas to the base of the odontoid process and body of the axis, where they are continuous with the commencement of the anterior common ligament. The fibres in the middle form a thick band which is tense in all positions of the joints ; the lateral portions are thin, and assist in limiting the rotation of the atlas on the axis.

The **posterior ligament** is a thin, membranous layer, passing between the posterior arch of the atlas and the laminæ of the axis ; it represents the ligamenta subflava in a rudimentary state, and has on its deep surface a layer of dense elastic fibres, like those of the latter.

The **capsular ligaments** surround the articular process of the atlas and axis ; they are loose, to permit of the free movement which exists between these vertebræ. The ligamentous fibres are most numerous on the outer and anterior part of the articulation ; and the synovial membrane usually communicates with the synovial cavity between the transverse ligament and odontoid process.

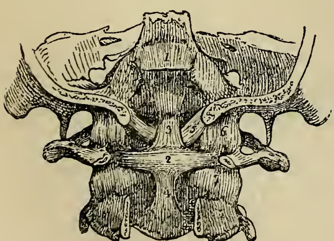


FIG. 152.—Posterior view of the ligaments connecting the atlas, axis, and occipital bone. The posterior part of the occipital bone has been sawn away, and the arches of the atlas and axis removed. 1. Superior part of the occipito-axial ligament, which has been cut away in order to show the ligaments beneath. 2. Transverse ligament of the atlas. 3, 4. Ascending and descending slips of the transverse ligament, which have obtained for it the title of cruciform ligament. 5. One of the lateral odontoid ligaments; the fellow-ligament is seen on the opposite side. 6. One of the occipito-atlantal capsular ligaments. 7. One of the atlanto-axial capsular ligaments.

The **transverse ligament** is a strong ligamentous band, which arches across the area of the ring of the atlas from a rough tubercle

on the inner surface of one articular process to a corresponding tubercle on the other; and serves to retain the odontoid process of the axis in connection with the anterior arch of the atlas. As it crosses the neck of the odontoid process, some fibres are sent downwards to be attached to the body of the axis, and others pass upwards to be inserted into the basilar process of the occipital bone; hence the ligament has a cross-like appearance, and is termed *cruciform.* A synovial membrane is situated between the transverse ligament and odontoid process; and another between that process and the anterior arch of the atlas.

Actions.—It is the peculiar disposition of the transverse ligament in relation to the odontoid process that enables the atlas, and with it the entire cranium, to rotate upon the axis; the perfect freedom of movement between these bones being ensured by the two synovial membranes. The lower part of the ring, formed by the transverse ligament with the atlas, is smaller than the upper, while the summit of the odontoid process is larger than its base; hence the process is retained in its place by the transverse ligament when the other ligaments are cut through. The extent to which rotation of the head upon the axis can be carried, is determined by the odontoid or check ligaments. The odontoid process with its ligaments is covered in by the occipito-axial ligament.

5. **ARTICULATION OF THE LOWER JAW.**—The ligaments of this articulation are the following:—

External lateral,	Capsular,
Two internal lateral,	Interarticular fibro-cartilage,
Two synovial membranes.	

The **external lateral ligament** is a short and thick band of fibres, passing obliquely backwards from the tubercle of the zygoma, to the external surface of the neck of the lower jaw. It is incorporated with the capsular ligament, and is, in relation, externally, with the integument of the face; internally, with the two synovial membranes of the articulation and the interarticular cartilage. The external lateral ligament acts conjointly with its fellow of the opposite condyle in the movements of the jaw.

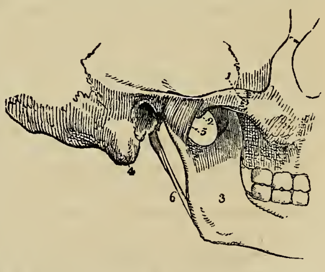


FIG. 153.—External view of the articulation of the lower jaw. 1. Zygomatic arch. 2. Tubercle of the zygoma. 3. Ramus of the lower jaw. 4. Mastoid portion of the temporal bone. 5. External lateral ligament. 6. Stylo-maxillary ligament.

The **short internal lateral ligament** has a broad attachment above to the outer part of the spine of the sphenoid, and is inserted below into the ridge on the inner side of the neck of the condyle. It is intimately connected with the capsule, and is separated from the long internal lateral ligament by fat and areolar tissue.

The **long internal lateral ligament** (spheno-maxillary) is a thin aponeurotic expansion extending from the extremity of the spinous

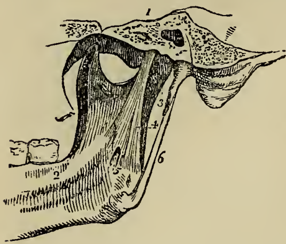


Fig. 154.—Internal view of the articulation of the lower jaw. 1. Section through the petrous portion of the temporal bone and spinous process of the sphenoid. 2. Internal surface of the ramus and body of the lower jaw. 3. Capsular ligament. 4. Long internal lateral ligament. 5. A small interval at its insertion through which the mylo-hyoidean nerve passes. 6. Stylo-maxillary ligament, a process of the deep cervical fascia.

process of the sphenoid bone to the margin of the dental foramen; it is pierced at its insertion by the mylo-hyoidean nerve.

Between the internal lateral ligament and neck of the jaw is a triangular space, in which are situated the internal maxillary artery, auriculo-temporal nerve, inferior dental artery and nerve, and part of the external pterygoid muscle; internally the ligament is in relation with the internal pterygoid muscle.

The middle meningeal artery in its upward course to the foramen spinosum, and the inferior dental nerve as it passes downwards to the dental canal, run along the side of this ligament.

The **capsular ligament** consists of numerous irregular ligamentous fibres, which pass from the edge of the glenoid cavity to the neck of the lower jaw, and surround the articulation. The capsule is thickest where it receives the accessory fibres called external and short internal lateral ligaments; it has inserted into it anteriorly a few fibres of the external pterygoid muscle.

The **interarticular fibro-cartilage** is a thin oval plate, thicker at the edges than in the centre, placed horizontally between the head of the condyle of the lower jaw and the glenoid cavity. Its upper surface is, from before backwards, concave anteriorly and slightly convex posteriorly, the former portion fitting the eminentia articularis, and the latter the glenoid cavity; its under surface is concave to receive the convex condyle. It is connected by its outer border with the external lateral ligament, and receives in front some fibres of insertion of the external pterygoid muscle. It divides the joint into two cavities, one being above, the other below, the cartilage; but it is occasionally incomplete in the centre.

The **synovial membranes** are situated, one above, the other below the fibro-cartilage, the former being the larger of the two. When the fibro-cartilage is perforated, the synovial membranes communicate.

Besides the lower jaw, there are several other joints provided with a complete interarticular cartilage, and, consequently, with two synovial membranes; they are—the *sterno-clavicular*, *acromio-clavicular*, and *the articulation of the ulna* with the *cuneiform bone.*

The interarticular fibro-cartilages of the *knee-joint* are partial, and there is but one synovial membrane. The articulations of the heads of the ribs with the vertebræ have two synovial membranes separated by an interarticular ligament without fibrous cartilage.

Connected with the lower jaw, though not with the joint, is the **stylo-maxillary ligament**, a process of the deep cervical fascia extended between the point of the styloid process and the angle of the jaw. It is attached to the jaw between the insertions of the masseter and internal pterygoid muscle, and separates the parotid from the submaxillary gland.

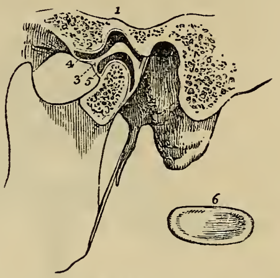


FIG. 155.—In this sketch a section has been made through the joint to show the position of the interarticular fibro-cartilage, and the manner of its adaptation to the articulating surfaces. 1. Glenoid fossa. 2. Eminentia articularis. 3. Interarticular fibro-cartilage. 4. Superior synovial cavity. 5. Inferior synovial cavity. 6. An interarticular fibro-cartilage, removed from the joint, in order to show its oval and concave form; it is seen from below.

Actions.—The movements of the lower jaw are—*depression*, by which the mouth is opened; *elevation*, by which it is closed; a *forward* and *backward* movement; and a movement from *side* to *side*.

In the movement of *depression* the interarticular cartilage glides forward on the eminentia articularis, carrying with it the condyle. If this movement be carried too far, the superior synovial membrane is ruptured, and dislocation of the fibro-cartilage with its condyle into the zygomatic fossa occurs. In *elevation* the fibro-cartilage and condyle are returned to their original position. The *forward* and *backward* movement is a gliding of the fibro-cartilage on the glenoid articular surface, in the antero-posterior direction; and the movement from *side to side*, in the lateral direction. The articulation between the condyle and fibro-cartilage forms a true ginglymus or hinge-joint, that between the fibro-cartilage and eminentia articularis an arthrodial or gliding joint.

6. **ARTICULATION OF THE RIBS WITH THE VERTEBRÆ.**—The ligaments of these articulations are remarkable for their strength, being in fact so strong as to render dislocation impossible; the neck of the rib must break before displacement could occur: they are divisible into two groups:—(1) Those connecting the *head of the rib* with the bodies of the *vertebræ;* and (2) Those connecting the *neck* and *tubercle of the rib* with the *transverse processes.*

1st Group.	*2d Group.*
Anterior costo-vertebral or stellate,	Anterior costo-transverse,
Capsular,	Middle costo-transverse,
Interarticular ligament,	Posterior costo-transverse.
Two synovial membranes.	

The **anterior costo-vertebral** or **stellate ligament** (costo-central, fig. 146) consists of three short bands of ligamentous fibres which radiate from the anterior part of the head of the rib. The *superior band* passes upwards to be attached to the vertebra above; the *middle fasciculus* is attached to the intervertebral substance; the *inferior* to the vertebra below.

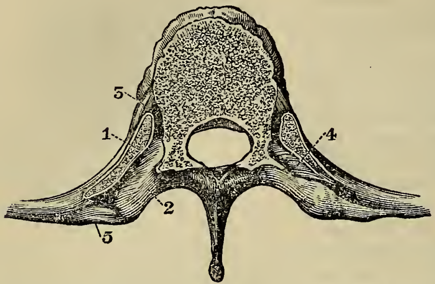


FIG. 156.—Transverse section of dorsal vertebra and heads of ribs. 1. Head of rib. 2. Transverse process of vertebra. 3. Anterior costo-vertebral or stellate ligament. 4. Interosseous costo-transverse ligament. 5. Posterior costo-transverse ligament.

In the **first** rib the ligament is not divided, but its fibres pass to the body of the last cervical as well as the first dorsal. In like manner the ligaments connected with the **eleventh** and **twelfth** ribs pass to the body of the vertebra above, as well as to that with which the head of the rib articulates.

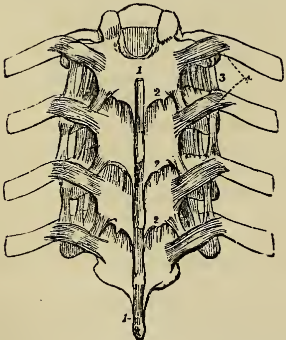


FIG. 157.—Posterior view of part of the thoracic portion of the vertebral column, showing the ligaments connecting the vertebræ with each other and the ribs with the vertebræ. 1, 1. Supraspinous ligament. 2, 2, 2. Ligamenta subflava, connecting the laminæ. 3. Anterior costo-transverse ligament. 4. Posterior costo-transverse ligaments.

The **capsular ligament** is a thin layer of ligamentous fibres surrounding the joint in the interval left by the anterior ligament; it is thickest above and below the articulation, and protects the synovial membranes.

The **interarticular ligament** is a thin band which passes between the sharp crest on the head of the rib and the intervertebral substance. It divides the joint into two cavities, each being furnished with a separate *synovial membrane.* The **first, tenth, eleventh,** and **twelfth** ribs have no interarticular ligament, and consequently but one synovial membrane.

The **anterior** (or **superior**) **costo-transverse ligament** is a broad band composed of two fasciculi, which ascend from the crest-like ridge on the neck of the rib, to the transverse process immediately above. This ligament separates the anterior from the dorsal branch of the intercostal nerve; it is absent from the first and last ribs.

The **middle costo-transverse ligament** is a strong interosseous

ligament passing directly between the posterior surface of the neck of the rib, and the anterior surface of the transverse process against which it rests. It is absent in the first and two inferior ribs.

The **posterior costo-transverse ligament** is a small but strong fasciculus, passing obliquely from the tubercle of the rib to the apex of the transverse process. The articulation between the tubercle of the rib and the transverse process is provided with a small synovial membrane.

There is no anterior costo-transverse ligament to the first or last rib; and only rudimentary posterior costo-transverse ligaments to the eleventh and twelfth ribs. Several accessory bands are found passing between the transverse processes and the ribs; a broad band of this kind connects the last rib with the transverse process of the first or second lumbar vertebra.

Actions.—The movements permitted by the articulations of the ribs are *upwards*, *downwards*, and slightly *forwards* and *backwards;* the movement increasing in extent from the head to the extremity of the rib. The forward and backward movement is trifling in the seven superior, but greater in the inferior ribs; the eleventh and twelfth are very movable.

7. ARTICULATION OF THE COSTAL CARTILAGES WITH THE STERNUM, AND WITH EACH OTHER.—The ligaments of the chondro-sternal articulations are :—

Anterior chondro-sternal,	Superior chondro-sternal,
Posterior chondro-sternal,	Inferior chondro-sternal,

Synovial membranes.

The **anterior chondro-sternal ligament** (anterior stellate ligament) is a thin band of ligamentous fibres, passing in a radiated direction from the extremity of the costal cartilage to the anterior surface of the sternum, and intermingling its fibres with those of the ligament of the opposite side, and with the tendinous fibres of origin of the pectoralis major muscle.

The **posterior chondro-sternal ligament**, much smaller than the anterior, consists of a thin fasciculus of fibres, situated on the posterior surface of the articulation.

The **superior** and **inferior chondro-sternal ligaments** are narrow fasciculi corresponding with the breadth of the cartilage, and connecting its superior and inferior border with the side of the sternum.

The **synovial membrane** is absent in the articulation of the first rib, its cartilage being usually adherent to the sternum; that of the second rib has an interarticular ligament, with two synovial membranes; the synovial membranes of the other costal cartilages are single.

The **sixth** and **seventh** ribs have several fasciculi of strong ligamentous fibres, passing from the extremity of their cartilages to the anterior surface of the ensiform cartilage, which latter they are intended to support. They are named the **chondro-xyphoid ligaments.**

The **sixth**, **seventh**, and **eighth**, and sometimes the **fifth** and the **ninth** costal cartilages, have articulations with each other, and a synovial membrane for each articulation. They are connected by ligamentous fibres (*ligamenta corruscantia*), which pass from one cartilage to the other, *external* and *internal ligaments.*

The **ninth** and **tenth** are connected at their extremity by ligamentous fibres, but have no synovial membrane.

Actions.—The movements of the chondro-sternal articulations are very trifling, being limited to a slight degree of sliding motion. The first rib is the least, the second the most movable.

8. **ARTICULATION OF THE RIBS WITH THE COSTAL CARTILAGES.**—The anterior extremity of each rib is excavated, so as to receive the convex outer end of the costal cartilage; there is no true ligament, but the periosteum is prolonged on the cartilage, and takes the place of one. No motion takes place at this articulation.

9. **ARTICULATION OF THE STERNUM.**—The pieces of the sternum are connected by means of a thin plate of interosseous cartilage placed between each, and by an anterior and posterior ligament. The fibres of the **anterior sternal ligament** are longitudinal in direction, but so blended with the anterior chondro-sternal ligaments and tendinous fibres of origin of the pectoral muscles, as scarcely to be distinguished as a distinct ligament. The **posterior sternal ligament** is a broad smooth plane of longitudinal fibres, placed on the posterior surface of the bone, and extending from the manubrium to the ensiform cartilage. These ligaments contribute very materially to the strength of the sternum and elasticity of the front of the chest; their continuation downwards on the ensiform cartilage constitutes the **sterno-xyphoid ligaments.**

10. **ARTICULATION OF THE VERTEBRAL COLUMN WITH THE PELVIS.**—The last lumbar vertebra is connected with the sacrum by the same ligaments as those with which the various vertebræ are connected to each other: viz., anterior and posterior common ligament, intervertebral substance, ligamenta subflava, capsular ligaments, interspinous and supraspinous ligament.

There are, however, *two* proper ligaments connecting the vertebral column with the pelvis; these are the

Sacro-lumbar, Ilio-lumbar.

The **sacro-lumbar** or **sacro-vertebral ligament** is a thick triangular fasciculus of ligamentous fibres, connected above with the lower and front part of the transverse process of the last lumbar vertebra, and below with the upper border of the sacrum, becoming blended with the anterior sacro-iliac ligament.

The **ilio-lumbar ligament** passes from the apex of the transverse process of the last lumbar vertebra to that part of the crest of the ilium which surmounts the sacro-iliac articulation. It is triangular in form, and gives origin to the quadratus lumborum and a few fibres of the iliacus muscle.

11. **ARTICULATIONS OF THE PELVIS.**—The ligaments of the articulations of the pelvis are divisible into four groups :—(1) Those connecting the *sacrum* and *ilium;* (2) those passing between the *sacrum* and *ischium;* (3) between the *sacrum* and *coccyx;* and (4) between the *two pubic bones.*

1st, *Between the sacrum and ilium.*
Sacro-iliac anterior,
Sacro-iliac posterior.

2d, *Between the sacrum and ischium.*
Lesser sacro-ischiatic,
Greater sacro-ischiatic.

3d, *Between the sacrum and coccyx.*
Sacro-coccygean anterior,
Sacro-coccygean posterior.

4th, *Between the ossa pubis.*
Anterior pubic, Superior pubic,
Posterior pubic, Sub-pubic,
Interosseous fibro-cartilage.

1. Between the Sacrum and Ilium.—This joint is commonly known as the *sacro-iliac synchondrosis*, but is sometimes called the *sacro-iliac symphysis;* it belongs to the class amphi-arthrosis.

The **anterior sacro-iliac ligament** consists of numerous short ligamentous bands and fibres, which pass from bone to bone on the anterior surface of the joint.

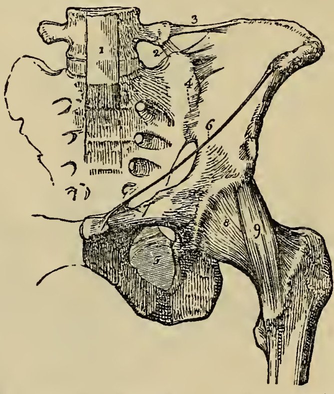


Fig. 158.—Ligaments of the pelvis and hip-joint. 1. Lower part of the anterior common ligament of the vertebræ, extending downwards over the front of the sacrum. 2. Sacro-lumbar ligament. 3. Ilio-lumbar ligament. 4. Anterior sacro-iliac ligament. 5. Obturator membrane. 6. Poupart's ligament. 7. Gimbernat's ligament. 8. Capsular ligament of the hip-joint. 9. Ilio-femoral or accessory ligament.

The **posterior sacro-iliac** or **interosseous ligament** is composed of numerous strong fasciculi of ligamentous fibres, which pass horizontally between the rough surfaces of the *posterior half* of the sacro-iliac articulation, and constitute the principal bond of connection between the sacrum and ilium. They are lodged in the hollow between the posterior surface of the sacrum and the backward projection of the ilium. One fasciculus of this ligament, longer and larger than the rest, is distinguished, from its direction, by the name of **oblique sacro-iliac ligament.** It is attached, by one extremity, to the pos-

teriorol superior spine of the ilium; and, by the other, to the third transverse tubercle on the posterior surface of the sacrum.

A **superior** and an **inferior ligament** are sometimes described, but as these are merely continuations of the anterior and posterior ligaments on the upper and lower surfaces of the articulation, they do not call for a separate description.

The surfaces of the two bones forming the sacro-iliac articulation are partly connected by cartilage, and partly rough and connected by the interosseous ligament. The **anterior** or **auricular half** is coated by a layer of cartilage which binds the corresponding surfaces of the ilium and sacrum together; when the two bones are forcibly separated this cartilage sometimes adheres to the ilium, sometimes to the sacrum, and occasionally splits equally or unequally. In some instances there are two plates of cartilage with a small cavity between them, and this arrangement is more common in the female than in the male.

2. Between the Sacrum and Ischium. — The **anterior** or **lesser sacro-ischiatic ligament** is thin and triangular in form; it is attached by its apex to the spine of the ischium, and by its broad extremity to the side of the sacrum and coccyx, interlacing its fibres with the greater sacro-ischiatic ligament.

The lesser sacro-ischiatic ligament is *in relation*, in front, with the coccygeus muscle; behind, with the posterior ligament, with which

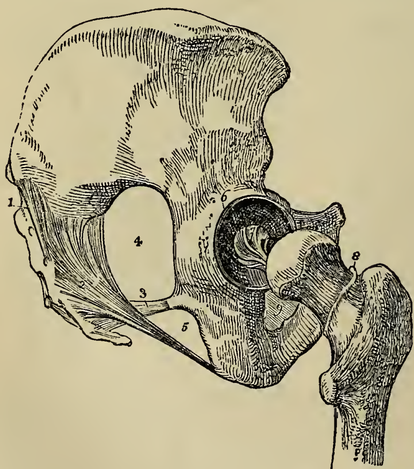


Fig. 159.—Ligaments of the pelvis and hip-joint, lateral view. 1. Oblique sacro-iliac ligament. The other fasciculi of the posterior sacro-iliac ligament are not seen in this view of the pelvis. 2. Greater sacro-ischiatic ligament. 3. Lesser sacro-ischiatic ligament. 4. Great sacro-ischiatic foramen. 5. Lesser sacro-ischiatic foramen. 6. Cotyloid ligament of the acetabulum. 7. Ligamentum teres. 8. Cut edge of the capsular ligament, showing its extent posteriorly, as compared with its anterior attachment. 9. Obturator membrane, only partly seen.

its fibres are intermingled. By its upper border it forms part of the lower boundary of the great sacro-ischiatic foramen, and by the lower, part of the lesser sacro-ischiatic foramen.

The **posterior** or **greater sacro-ischiatic ligament**, larger,

thicker, and posterior to the preceding, is narrower in the middle than at each extremity. It is attached, by its smaller end, to the inner margin of the tuberosity and ramus of the ischium, where it forms a falciform process, which protects the internal pudic artery, and is continuous with the obturator fascia. By its larger extremity it is inserted into the side of the coccyx, sacrum, posterior inferior spine, and extremity of the crest of the ilium.

The greater sacro-ischiatic ligament is *in relation*, in front, with the lesser ligament; behind, with the gluteus maximus, to some fibres of which it gives origin. By its superior border it forms part of the boundary of the lesser ischiatic foramen, and, by its lower border, part of the boundary of the perinæum. It is pierced by the coccygeal branch of the ischiatic artery. The two ligaments convert the sacro-ischiatic notches into foramina.

3. Between the Sacrum and Coccyx.—The **anterior sacro-coccygean ligament** is a thin fasciculus passing from the anterior surface of the sacrum to the front of the coccyx, and is continuous with the anterior common ligament.

The **posterior sacro-coccygean ligament** is a thick ligamentous layer, which completes the lower part of the sacral canal, and connects the sacrum with the coccyx posteriorly, extending as far as the apex of the latter bone. It is a direct continuation of the posterior common ligament, and becomes connected with the termination of the supraspinous ligament, and the filum terminale of the spinal cord.

Between the two bones is a thin intervertebral disc of fibro-cartilage; and in females not unfrequently a synovial membrane. The articulation admits of a certain degree of movement backwards during parturition.

The ligaments connecting the different pieces of the coccyx consist of a few scattered *anterior* and *posterior* fibres, and a thin disc of interosseous cartilage; the latter exists only in the young subject, as, in the adult, the pieces become ossified.

4. Between the Ossa Pubis.—This articulation receives the name of *symphysis pubis;* it is an example of an amphi-arthrodial joint.

The **anterior pubic ligament** is composed of ligamentous fibres, which pass obliquely across the union of the two bones from side to side, and form an interlacement in front of the symphysis.

The **posterior pubic ligament** consists of a few irregular bands of fibres uniting the pubic bones posteriorly.

The **superior pubic ligament** is a thick band of fibres connecting the angles of the ossa pubis superiorly, and filling the inequalities of the surface of the bones.

The **sub-pubic ligament** is a thick arch of fibres connecting the two bones inferiorly, and forming the upper boundary of the pubic arch.

The **interosseous fibro-cartilage** unites the two surfaces of the pubic bones in the same manner as the intervertebral substance con-

nects the bodies of the vertebræ. It resembles the intervertebral substance also in being composed of oblique fibres disposed in concentric layers, which are more dense towards the surface than near the centre. It is thick in front, and thin behind; and a synovial membrane is found in the upper and posterior part of the articulation.

This articulation becomes movable towards the latter term of pregnancy, and admits of a slight degree of separation of its surfaces.

The **obturator membrane** is not a ligament of articulation, but simply a ligamentous membrane stretched across the obturator foramen. It gives attachment by its surfaces to the two obturator muscles, and leaves a space in the upper part of the foramen for the passage of the obturator vessels and nerve.

The numerous vacuities in the walls of the pelvis, and their closure by ligamentous structures, as in the case of the sacro-ischiatic and obturator foramina, serve to diminish the pressure on the soft parts during the passage of the head of the fœtus through the pelvis in parturition.

LIGAMENTS OF THE UPPER EXTREMITY.

The **ligaments of the upper extremity** may be arranged in the order of the articulations of the different bones; they are:—

1. Sterno-clavicular articulation.
2. Scapulo-clavicular articulation.
3. Ligaments of the scapula.
4. Shoulder-joint.
5. Elbow-joint.
6. Radio-ulnar articulation.
7. Wrist-joint.
8. Articulation between the carpal bones.
9. Carpo-metacarpal articulation.
10. Metacarpo-phalangeal articulation.
11. Articulation of the phalanges.

1. **STERNO-CLAVICULAR ARTICULATION.**—The sterno-clavicular is an arthroidal articulation; its ligaments are: —

Anterior sterno-clavicular, Inter-clavicular,
Posterior sterno-clavicular, Costo-clavicular (*rhomboid*),
Interarticular fibro-cartilage,
Two synovial membranes.

The **anterior sterno-clavicular ligament** is a broad ligamentous layer, extending obliquely downwards and inwards, and covering the anterior aspect of the articulation. This ligament is *in relation* by its anterior surface with the integument and sternal origin of the sterno-mastoid muscle; and behind with the interarticular fibro-cartilage and synovial membranes.

The **posterior sterno-clavicular ligament**, thicker and stronger than the anterior, is a broad band covering the posterior surface of

the articulation. It is *in relation* by its anterior surface with the interarticular fibro-cartilage and synovial membranes; and behind, with the sterno-hyoid and sterno-thyroid muscle.

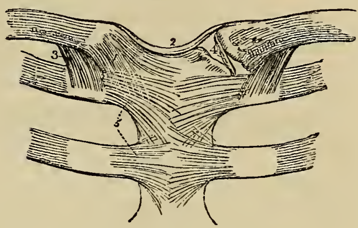


Fig. 160.—Ligaments of the sterno-clavicular and chondro-sternal articulations. 1. Anterior sterno-clavicular ligament. 2. Inter-clavicular ligament. 3. Costo-clavicular or rhomboid ligament, seen on both sides. 4. Interarticular fibro-cartilage, brought into view by the removal of the anterior and posterior ligaments. 5. Anterior chondro-sternal ligaments of the first and second ribs.

The anterior and posterior sterno-clavicular ligaments, together with a few short fibres connecting the bones above, are sometimes described as forming one ligament, which is then called *capsular.*

The **inter-clavicular ligament** is a cord-like band which crosses from the extremity of one clavicle to that of the other, and is closely adherent to the upper border of the sternum. It is separated by areolar tissue from the sterno-thyroid muscles.

The **costo-clavicular** or **rhomboid ligament** is a thick fasciculus of fibres, connecting the sternal extremity of the clavicle with the cartilage of the first rib. It is placed obliquely between the rib and under surface of the clavicle; and is *in relation*, in front, with the tendon of origin of the subclavius muscle, and behind with the subclavian vein.

The **interarticular fibro-cartilage** is nearly circular in form, and thicker at the edges than in the centre. It is attached above, to the clavicle; below, to the cartilage of the first rib; and throughout the rest of its circumference, to the anterior and posterior sterno-clavicular ligament. It divides the joint into two cavities, which are lined by separate *synovial membranes;* is sometimes pierced through its centre, and not unfrequently deficient, to a greater or less extent, at its lower part.

One of the **synovial cavities** lies between the end of the clavicle and interarticular cartilage, the other between the sternum and the cartilage; the former is more loose than the latter.

Actions.—The movements of the sterno-clavicular articulation are—a *gliding movement* of the fibro-cartilage with the clavicle, on the articular surface of the sternum, in the directions forward, backward, upward, and downward; and *circumduction.* The upward and downward movements take place between the clavicle and interarticular cartilage, the forward and backward movements between the cartilage and the sternum; in circumduction the two portions of the articulation alternately take part in the movement. This articulation is the centre of the movements of the shoulder.

2. **SCAPULO-CLAVICULAR ARTICULATION.**—The ligaments of the scapular end of the clavicle are :—

Superior acromio-clavicular,
Inferior acromio-clavicular,
Coraco-clavicular (*trapezoid* and *conoid*),
Interarticular fibro-cartilage,
Two synovial membranes.

The **superior acromio-clavicular ligament** is a moderately thick plane of fibres passing between the extremity of the clavicle and the acromion, on the upper surface of the joint. It is strengthened by the tendinous fibres of the trapezius and deltoid, and on its deep surface is connected with the interarticular cartilage.

The **inferior acromio-clavicular ligament** is a thin plane situated on the under surface. These two ligaments are continuous with each other in front and behind, and form a *capsule* around the articulation.

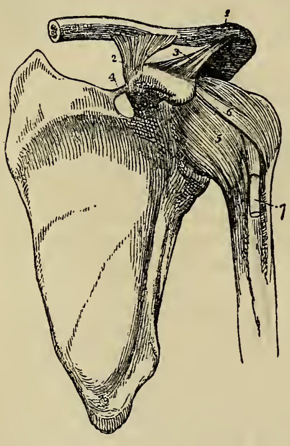


Fig. 161.—Ligaments of the scapula and shoulder-joint. 1. Superior acromio-clavicular ligament. 2. Coraco-clavicular ligament; this aspect of the ligament is named trapezoid. 3. Coraco-acromial ligament. 4. Transverse ligament. 5. Capsular ligament. 6. Coraco-humeral ligament. 7. The long tendon of the biceps issuing from the capsular ligament, and entering the bicipital groove.

The **coraco-clavicular ligament** is a thick fasciculus of ligamentous fibres, passing obliquely between the base of the coracoid process and under the surface of the clavicle, and holding the end of the clavicle in firm connection with the scapula. It is divisible into two parts, an anterior and external called **trapezoid,** and a posterior and internal called **conoid.** The trapezoid portion is seen best from the front; it is attached below to the upper surface of the coracoid process and above to the oblique line on the under surface of the clavicle; its anterior border is free, its posterior joins with the conoid portion. The conoid ligament has its base directed upwards and attached to the conoid tubercle on the under surface of the clavicle; its apex is inserted into a rough process at the base of the coracoid process of the scapula.

The **interarticular fibro-cartilage** is often indistinct, from having partial connections with the fibro-cartilaginous surfaces of the two bones between which it is placed, and is frequently absent. When partial, it occupies the upper part of the articulation. The *synovial membranes* are thin; and when the fibro-cartilage is incomplete, there is but one.

Actions.—The acromio-clavicular articulation admits of two movements, *gliding* of the surfaces on each other, and *rotation* of the scapula on the extremity of the clavicle.

Bursæ.—There are commonly *three* bursæ in connection with this articulation; one in the recess between the trapezoid and conoid ligaments, one between the base of the coracoid process and apex of the conoid ligament, and the third between the coraco-acromial ligament and the capsule of the shoulder-joint.

3. The **PROPER LIGAMENTS OF THE SCAPULA** are:—

Coraco-acromial, Transverse.

The **coraco-acromial ligament** is a broad and thick triangular band, which forms a protecting arch over the shoulder-joint. It is attached by its apex to the point of the acromion process, and by its base to the external border of the coracoid process its whole length. This ligament is *in relation* above with the under surface of the deltoid muscle; and below with the tendon of the supra-spinatus muscle, a bursa mucosa being usually interposed.

The **transverse** or **coracoid ligament** (supra-scapular) is a narrow but strong fasciculus which crosses the notch in the upper border of the scapula, from the base of the coracoid process, and converts it into a foramen. The supra-scapular nerve passes through this foramen, the artery over it. The omo-hyoid muscle takes origin from this ligament.

4. **SHOULDER-JOINT.**—The scapulo-humeral articulation is an enarthrosis, or ball-and-socket joint; its ligaments are:—

Capsular, Coraco-humeral, Glenoid,
Gleno-humeral.

The **capsular ligament** encloses the articulating head of the scapula and head of the humerus, and is attached above to the neck of the scapula externally to the glenoid ligament, and to the root of the coracoid process; on the humerus it is attached to the upper half of the anatomical neck, but below it passes further from the articular surface, some of its deeper fibres being, however, reflected upwards to terminate at the articular margin, much in the same way as fibres are reflected on the neck of the femur in the hip. It is thick above, where resistance is most required, and strengthened by the tendons of the supra-spinatus, infra-spinatus, teres minor, and subscapularis muscles: below it is thin and loose. The tendons of all the muscles in contact with the capsule except the subscapularis can be readily separated from it by careful dissection, but the latter either has beneath it a bursa which communicates with the cavity of the joint, or is itself united with the capsule and lined by the synovial membrane of the articulation.

The **coraco-humeral ligament** is a broad band which descends obliquely outwards from the border of the coracoid process to the greater tuberosity of the humerus, and serves to strengthen the supe-

rior and anterior part of the capsular ligament; it assists the latter in bridging over the bicipital groove.

The **gleno-humeral ligament** is an accessory slip of fibres which projects into the joint along the inner edge of the biceps tendon, and is inserted into the upper part of the bicipital groove. It is supposed to be the homologue of the ligamentum teres in the hip-joint.

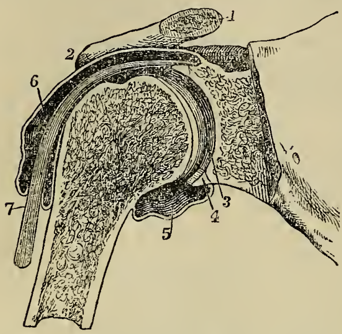


Fig. 162.—Section through the shoulder-joint. 1. The cut end of the clavicle. 2. Acromial end of the clavicle. 3. Articular surface of the glenoid cavity covered with cartilage. 4. Cross section of the glenoid ligament. 5. Lower part of capsule and synovial sac. 6. Synovial membrane prolonged on biceps tendon. 7. Tendon of biceps muscle.

The **glenoid ligament** is the prismoid band of fibro-cartilage, which is attached around the margin of the glenoid surface for the purpose of protecting its edge and deepening its cavity. It divides superiorly into two slips which are continuous with the long tendon of the biceps; hence the ligament is sometimes described as being formed by the splitting of that tendon. The cavity of the articulation is traversed by the long tendon of the biceps, which is enclosed in a sheath of synovial membrane in its passage through the joint.

The **synovial membrane** of the shoulder-joint is extensive; it communicates anteriorly through an opening in the capsular ligament with a large bursal sac, which lines the under surface of the tendon of the subscapularis muscle. Superiorly it frequently communicates through another opening in the capsular ligament with a bursal sac belonging to the infraspinatus muscle; and it moreover forms a sheath around that portion of the tendon of the biceps which is included within the joint.

Capsular Muscles.—The muscles immediately surrounding the shoulder-joint are—the subscapularis, supra-spinatus, infra-spinatus, teres minor, long head of the triceps, and deltoid; the long tendon of the biceps is within the capsular ligament.

Actions.—The shoulder-joint is capable of every variety of motion—viz., of movement forwards and backwards, of abduction and adduction, of circumduction and rotation. The great freedom of movement which this joint enjoys depends on the laxity of the capsule and the large size of the head of the humerus in comparison with the depth of the glenoid cavity. The capsule is so loose that if an opening be made in it the humerus will fall about an inch from the scapula, showing that the articular surfaces are not kept in contact by the fibres of the capsule, but by atmospheric pressure.

Bursæ.—The bursæ in connection with this joint are *four* in number: one between the subscapularis tendon and the capsule and

neck of the scapula; a second one between the capsule and the tendon nearer to the insertion of the latter; a third between the top of the coracoid process and the capsule; and a fourth between the combined origins of the biceps and coraco-brachialis and the capsule.

5. **ELBOW-JOINT.**—The elbow is a ginglymoid articulation; and its ligaments *four* in number, namely :—

Anterior,	Interal lateral,
Posterior,	External lateral.

The **anterior ligament** is a broad and thin membranous layer, descending from the anterior surface of the humerus immediately above the joint, to the coronoid process of the ulna and orbicular ligament. It is connected on each side with the lateral ligaments, and is composed of fibres which pass in three different directions, vertical, transverse, and oblique, the latter being extended downwards and outwards to the orbicular ligament, into which they are inserted inferiorly. This ligament is covered in by the brachialis anticus muscle.

Fig. 163.—Ligaments of the elbow-joint, inner side. 1. Anterior ligament. 2. Internal lateral ligament. 3. Orbicular ligament. 4. Oblique ligament. 5. Interosseous ligament. 6. Internal condyle of the humerus, which conceals the posterior ligament.

The **posterior ligament** is a broad and loose layer passing transversely across the olecranon fossa, and from the sides of the fossa to the base of the olecranon; it is connected at each side with the lateral ligaments. It is covered in by the tendon of the triceps.

The **internal lateral ligament** is a thick triangular layer, attached above, by its apex, to the internal condyle of the humerus; and below, by its expanded border, to the margin of the greater sigmoid cavity of the ulna, extending from the coronoid process to the olecranon. At its insertion it is intermingled with some transverse fibres; and posteriorly is in relation with the ulnar nerve.

The **external lateral ligament** is a strong and narrow band which descends from the external condyle of the humerus, to be inserted into the orbicular ligament and the ridge on the ulna with which the posterior part of the latter ligament is connected. This ligament is closely united with the tendon of origin of the supinator brevis muscle.

The four preceding ligaments are sometimes described as one under the name of *capsular* ligament.

The **synovial membrane** is extensive, and is reflected from the

cartilaginous surfaces of the bones upon the inner surface of the margins of the ligaments. It forms an articulating sac between the head of the radius and the lesser sigmoid notch of the ulna.

The muscles immediately surrounding and in contact with the elbow-joint are—*in front*, brachialis anticus; *inner side*, pronator radii teres, flexor sublimis digitorum, and flexor carpi ulnaris; *externally*, extensor carpi radialis brevior, extensor communis digitorum, extensor carpi ulnaris, anconeus, and supinator brevis; *behind*, triceps.

FIG. 164.—External view of the elbow-joint. 1. Humerus. 2. Ulna. 3. Radius. 4. External lateral ligament inserted inferiorly into (5) the orbicular ligament. 6. Posterior extremity of the orbicular ligament, spreading out at its insertion into the ulna. 7. Anterior ligament, scarcely apparent in this view of the articulation. 8. Posterior ligament, thrown into folds by the extension of the joint.

Actions.—The movements of the elbow-joint are *flexion* and *extension*; the extent of these movements being limited, in front by the coronoid process, and behind by the olecranon.

Bursæ.—The bursæ in connection with this joint are only *three* in number: the first of these lies between the tendons of the extensor carpi radialis brevior and extensor communis digitorum, and the external lateral ligament; the second between the olecranon and posterior ligament; and the third between the olecranon and the superficial structures.

6. RADIO-ULNAR ARTICULATION.

—The radius and ulna are firmly held together by ligaments, connected with both extremities of the bones, and with the shaft; they are :—

Orbicular,	Anterior inferior radio-ulnar.
Oblique,	Posterior inferior radio-ulnar.
Interosseous,	Interarticular fibro-cartilage.

The **orbicular ligament (annular, coronary)** is a firm band, several lines in breadth, which surrounds the head of the radius, and is attached by each end to an extremity of the lesser sigmoid cavity. Some of the lower fibres are continued round beneath the sigmoid cavity so as to form a complete circle. It is strongest behind where it receives the external lateral ligament, and is lined on its inner surface by a reflection of the synovial membrane of the elbow-joint; it gives attachment to fibres of the supinator brevis muscle.

The rupture of this ligament permits the dislocation of the head of the radius.

The **oblique ligament** is a narrow slip of ligamentous fibres, descending obliquely from the base of the coronoid process of the ulna to the inner side of the radius, a little below its tuberosity.

Its fibres run in the opposite direction to those of the interosseous membrane.

The **interosseous membrane** is a broad and thin plane of aponeurotic fibres passing obliquely downwards from the sharp ridge on the radius to that on the ulna. It is deficient superiorly, broader in the middle than at each extremity, and perforated at its lower part for the passage of the anterior interosseous artery. The posterior interosseous artery passes backwards between the oblique ligament and upper border of the interosseous membrane.

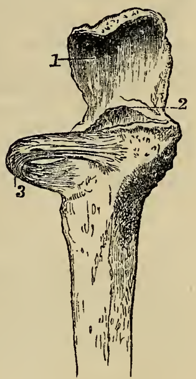


FIG. 165.—Upper part of ulna and orbicular ligament. 1. Olecranon. 2. Tip of coronoid process. 3. Orbicular ligament.

The interosseous membrane affords an extensive surface for the attachment of muscles; and is *in relation*, *in front*, with the flexor profundus digitorum, flexor longus pollicis, pronator quadratus, and anterior interosseous artery and nerve; *behind*, with the supinator brevis, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensor secundi internodii pollicis, extensor indicis, and near the wrist with the anterior interosseous artery and posterior interosseous nerve.

The **anterior inferior radio-ulnar ligament** is a thin band of fibres, passing transversely between the *anterior surface* of the lower end of the radius and ulna.

The **posterior inferior radio-ulnar ligament**, also thin and loose, has the same disposition on the posterior surface of the articulation.

The **triangular interarticular fibro-cartilage** acts the part of a ligament between the lower extremity of the radius and ulna. It is inserted by its apex into a depression on the inner surface of the styloid process of the ulna, and attached by its base to the edge of the radius. This fibro-cartilage is lined on the upper surface by a synovial membrane, which forms a remarkably loose capsule between the radius and ulna, and is called the *membrana sacciformis*. By its lower surface it enters into the articulation of the wrist-joint.

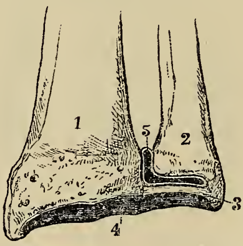


FIG. 166.—Lower end of radius and ulna, with articular surfaces. 1. Radius. 2. Ulna. 3. Interarticular fibro-cartilage. 4. Articular end of radius. 5. Membrana sacciformis.

Actions.—The movements taking place between the radius and ulna are—rotation of the former upon the latter, rotation forwards being termed *pronation*, and rotation backwards *supination*; in the former the palm of the hand comes to be directed

downwards, in the latter it looks upwards. In these movements the head of the radius turns upon its axis, within its orbicular ligament and lesser sigmoid notch of the ulna; while inferiorly, the radius presents a concavity which moves on the rounded head of the ulna. The movements of the radius are chiefly limited by the anterior and posterior inferior ligaments; hence these are not unfrequently ruptured in great muscular efforts.

7. **WRIST-JOINT.**—The wrist is a ginglymoid articulation; the articular surfaces entering into its formation being the radius and triangular fibro-cartilage above, and the rounded surface of the scaphoid, semilunar, and cuneiform bones below; its ligaments are *four* in number :—

Anterior,	Internal lateral,
Posterior,	External lateral.

The **anterior ligament** is a broad and membranous layer consisting of three fasciculi, which pass downwards and inwards between the anterior margin of the lower end of the radius and the scaphoid, semilunar, and cuneiform bones. It is pierced by numerous small

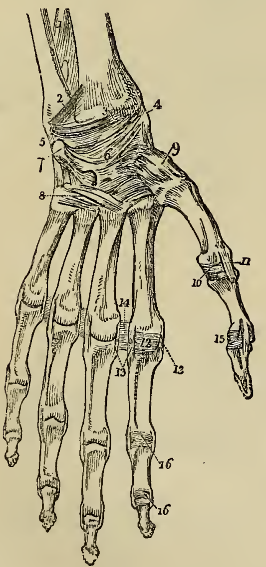


Fig. 167.—Ligaments of the anterior aspect of the wrist and hand. 1. Lower part of the interosseous membrane. 2. Antero-inferior radio-ulnar ligament. 3. Anterior ligament of the wrist-joint. 4. External lateral ligament. 5. Internal lateral ligament. 6. Palmar ligaments of the carpus. 7. Pisiform bone, with its ligaments. 8. Ligaments connecting the second range of carpal bones with the metacarpal, and the metacarpal with each other. 9. Capsular ligament of the carpo-metacarpal articulation of the thumb. 10. Anterior ligament of the metacarpo-phalangeal articulation of the thumb. 11. One of the lateral ligaments of that articulation. 12. Anterior ligament of the metacarpo-phalangeal articulation of the index finger; this ligament has been removed in the other fingers. 13, 13. Lateral ligaments of the same articulation: the corresponding ligaments are seen in the other articulations. 14. Transverse ligament connecting the heads of the metacarpal bones of the index and middle fingers; the same ligament is seen between the other fingers. 15. Anterior and one lateral ligament of the phalangeal articulation of the thumb. 16, 16. Anterior and lateral ligaments of the phalangeal articulations of the index finger; the anterior ligaments are removed in the other fingers, but the lateral ligaments remain.

openings for vessels, and has lying in front of it the tendons of the flexor profundus digitorum and flexor longus pollicis.

The **posterior ligament**, also thin and loose, passes downwards

and inwards between the posterior surface of the radius and the posterior surface of the semilunar and cuneiform bones.

The **internal lateral ligament** extends from the styloid process of the ulna to the cuneiform and pisiform bone.

The **external lateral ligament** is attached by one extremity to the styloid process of the radius, and by the other to the side of the scaphoid bone, some of its fibres being prolonged to the trapezium. The radial artery rests on this ligament as it passes backwards to the first metacarpal space.

The **synovial membrane** of the wrist-joint passes from the edge of the lower articular surface of the radius on to the ligaments, and from thence to the margins of the proximal articular surfaces of the scaphoid, semilunar, and cuneiform bones. The synovial cavity is separated from that formed by the membrana sacciformis by the triangular fibro-cartilage.

The **relations** of the wrist-joint are the flexor and extensor tendons by which it is surrounded, and the radial and ulnar artery.

Actions.—The movements of the wrist-joint are *flexion*, *extension*, *adduction*, *abduction*, and *circumduction.* In these motions the articular surfaces glide upon each other. No rotation takes place in this joint, the superior and inferior radio-ulnar joints being alone employed in the production of pronation and supination.

Bursæ.—The bursæ in connection with this joint chiefly take the form of synovial sheaths for the tendons ; those more immediately in relation with the ligaments are as follows :—One between the tendon of the flexor longus pollicis and the anterior ligament, one between the flexor profundus tendons and the same ligament, a third of rounded form between the tendon of the flexor carpi ulnaris and the internal lateral ligament, a fourth separating the radial extensors from the posterior ligaments, a fifth beneath the tendons of the common extensor, and a sixth beneath the tendon of the flexor carpi ulnaris.

8. **ARTICULATION BETWEEN THE CARPAL BONES.**—These are amphi-arthrodial joints, with the exception of the conjoined head of the os magnum and unciform, which is received into a cup formed by the scaphoid, semilunar, and cuneiform bone, and constitutes an enarthrosis. The ligaments are :—

Dorsal,	Interosseous fibro-cartilages,
Palmar,	Annular.

The **dorsal ligaments** are ligamentous bands that pass transversely and longitudinally from bone to bone on the dorsal surface of the carpus.

The **palmar ligaments** are fasciculi of the same kind, but stronger than the dorsal, having the like disposition on the palmar surface.

The **interosseous ligaments** are fibro-cartilaginous lamellæ situated between the adjoining bones in each range : in the upper range they close the upper part of the space between the scaphoid,

semilunar, and cuneiform bones; in the lower range they are stronger than in the upper, and connect the os magnum on the one side to the unciform, on the other to the trapezoid, leaving intervals through which the synovial membrane is continued to the bases of the metacarpal bones.

The **anterior annular ligament** is a firm ligamentous band, which connects the bones of the two sides of the carpus. It is attached by one extremity to the trapezium and scaphoid, by the other to the unciform process of the unciform and base of the pisiform bones, and forms an arch over the anterior surface of the carpus, beneath which the tendons of the long flexors and the median nerve pass into the palm of the hand.

The **posterior annular ligament** is a flattened band of fibrous tissue about half an inch in breadth, passing across from the lower end and styloid process of the radius to the cuneiform, pisiform, and base of the fifth metacarpal. It assists the posterior ligament of the wrist-joint in binding the hand to the fore-arm, and in carrying the hand with the radius in pronation. A more complete description of this ligament and the preceding will be found in the section on the muscles and fasciæ.

The **articulation of the pisiform bone** with the cuneiform is provided with a separate synovial membrane, protected by fasciculi of ligamentous fibres, which form a kind of capsule around the joint, and are inserted into the cuneiform bone. This bone is also connected with the unciform and base of the metacarpal of the little finger by two strong fibrous bands.

Synovial cavities.—There are *five* synovial cavities between the articulations of the carpus:—

The *first* is situated between the lower end of the ulna and the interarticular fibro-cartilage; it has been described above, and is called *sacciform*, on account of forming a sacculus between the ulna and radius.

The *second* is situated between the lower surface of the radius and interarticular fibro-cartilage *above*, and the first range of bones of the carpus *below*.

The *third*, the most extensive of the synovial cavities of the wrist, is situated between the two rows of carpal bones, and passes between the bones of the second range, and between the carpal extremities of the four metacarpal bones of the fingers.

The *fourth* is the synovial cavity of the articulation of the metacarpal bone of the thumb with the trapezium.

The *fifth* is situated between the pisiform and cuneiform bones.

Actions.—Very little movement exists between the bones in each range, but more is permitted between the two ranges. The most important movements are flexion and extension, but there is also a slight amount of lateral motion and of rotation in the medio-carpal articulation. The rotation takes place by the head of the os magnum and upper outer angle of the unciform moving in the socket formed by the three outer bones of the first row, together with some gliding

backwards and forwards of the trapezium and trapezoid on the scaphoid.

9. **CARPO-METACARPAL ARTICULATIONS.**—The second row of bones of the carpus articulates with the metacarpal bones of the four fingers by *dorsal* and *palmar* ligaments; and the metacarpal bone of the thumb with the trapezium by a *capsular ligament.*

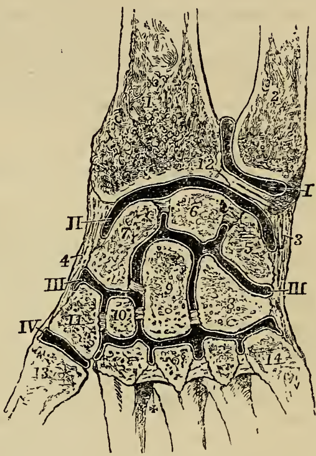


FIG. 168.—Diagram showing the disposition of the chief synovial membranes of the wrist-joint. I. Sacciform membrane. II. Second synovial cavity. III. Third or large synovial cavity. IV. Synovial cavity between the trapezium and metacarpal bone of thumb. That of the pisiform bone is here omitted. 1. Radius. 2. Ulna. 3. Internal lateral ligament. 4. External lateral ligament. 5. Cuneiform bone. 6. Semilunar. 7. Scaphoid. 8. Unciform. 9. Os magnum. 10. Trapezoid. 11. Trapezium. 12. Interarticular fibro-cartilage. 13. Metacarpal bone of thumb. 14. Metacarpal of little finger. + Interosseous metacarpal ligaments. Interosseous ligaments are also seen connecting the bones of each row of the carpus.

There is also in the carpo-metacarpal articulation a thin *interosseous* band, which passes from the ulnar edge of the os magnum to the base of the third and fourth metacarpal bones at their point of connection.

The **dorsal ligaments** are strong fasciculi which pass from the second range of carpal to the metacarpal bones; with the exception of the little finger there are two fasciculi to each bone, namely, to the index finger, one each from the trapezium and trapezoid; to the middle finger, one each from the trapezoid and os magnum; to the ring finger, one each from the os magnum and unciform; and to the little finger, one from the unciform.

The **palmar ligaments** are thin fasciculi arranged according to the same plan on the palmar surface, but the third metacarpal has three slips, one from the ridge on the trapezium, one from the os magnum, and one from the unciform.

The **synovial cavity** is a continuation of the great synovial cavity of the two rows of carpal bones.

The **capsular ligament** of the thumb is one of the three true capsular ligaments of the skeleton; the other two being the shoulder and hip. The articulation has a proper **synovial membrane.**

The **metacarpal bones** of the four fingers are firmly connected

at their bases by means of dorsal and palmar ligaments, which extend transversely from one bone to the other, and by interosseous ligaments which pass between their contiguous surfaces. Their lateral articular facets are lined by a reflection of the great synovial membrane of the two rows of carpal bones.

Actions.—The movements of the metacarpal on the carpal bones are restricted to a slight degree of sliding motion, with the exception of the articulation of the metacarpal bone of the thumb with the trapezium. In the latter, the movements are *flexion*, *extension*, *adduction*, *abduction*, and *circumduction*.

10. **METACARPO-PHALANGEAL ARTICULATION.**—The metacarpo-phalangeal articulation is a ginglymoid joint; and its ligaments four in number :—

Anterior, Two lateral, Transverse.

The **anterior ligaments** (glenoid), thick and fibro-cartilaginous, form part of the articulating surface of the joints. They are grooved on their palmar surface for the lodgment of the flexor tendons, and by their deep aspect form part of the articular surface for the head of the metacarpal bone. At each side they are continuous with the lateral ligaments.

The **lateral ligaments** are strong narrow fasciculi, holding the bones together at each side.

The **transverse ligament** is a strong ligamentous band passing across the heads of the metacarpal bones of the four fingers, and connected with the anterior ligaments.

The expansion of the extensor tendon over the back of the fingers takes the place, and performs the office, of a posterior ligament.

Actions.—The chief motions which this articulation admits of are *flexion* and *extension*; there is also some power of *abduction* and *adduction* in the extended position, but little in the flexed.

11. **ARTICULATION OF THE PHALANGES.**—These articulations are ginglymoid joints; and furnished with three ligaments :—

Anterior, Two lateral.

The **anterior ligament**, firm and fibro-cartilaginous, forms part of the articular surface for the head of the phalanges; while externally it is grooved for the reception of the flexor tendons.

The **lateral ligaments** are very strong, and the principal bond of connection between the bones.

The extensor tendon takes the place and performs the office of a posterior ligament.

Actions.—The movements of the phalangeal joints are *flexion* and *extension*, these movements being more free between the first and second than between the second and third.

In connection with the phalanges it will be proper to examine certain fibrous bands termed *thecæ* or *vaginal ligaments*, which serve

to retain the tendons of the flexor muscles against the flat surface of the bones. These fibrous bands are attached at each side to the lateral margins of the phalanges; they are thick in the interspaces of the joints, thin where the tendons lie upon the joints, and are lined on their inner surface by synovial membrane.

LIGAMENTS OF THE LOWER EXTREMITY.

The **ligaments of the lower extremity**, like those of the upper, may be arranged in the order of the joints to which they belong; these are :—

1. Hip-joint.
2. Knee-joint.
3. Articulations between the tibia and fibula.
4. Ankle-joint.
5. Articulations of the tarsal bones.
6. Tarso-metatarsal articulations.
7. Metatarso-phalangeal articulations.
8. Articulations of the phalanges.

1. **HIP-JOINT.**—The articulation of the head of the femur with the acetabulum constitutes an enarthrosis, or ball-and-socket joint. The articular surfaces are—the cup-shaped cavity of the acetabulum and the rounded head of the femur; the ligaments are *five* in number, viz. :—

Capsular,	Teres,
Ilio-femoral,	Cotyloid,
Transverse.	

The **capsular ligament** (fig. 158, 8) is a strong ligamentous capsule, embracing the acetabulum superiorly, the neck of the femur below, and connecting the two bones firmly together. The pelvic origin of the fibres extends superiorly as high as the base of the anterior inferior iliac spine, posteriorly it is connected with the ilium and ischium only a few lines from the margin of the acetabulum, inferiorly it is attached to the outer lip of the groove between the ischial tuberosity and acetabulum, while in front it springs from the transverse ligament, the pubes near the notch, and the pectineal eminence. On the femur the capsule gets attached in front to the spiral line, above to the base of the great trochanter, behind to the junction of the middle and outer thirds of the neck, and reaches below to within three-quarters of an inch of the lesser trochanter. The capsule is composed of longitudinal and circular fibres; the former are chiefly found on the front, and the latter are most numerous on the back. The longitudinal fibres at the back of the capsule are almost entirely confined to the surface next the synovial membrane; after running outwards for some distance they are reflected along the neck of the femur to the articular margin; from

their close connection with the bone they often prevent the separation of the fragments in intracapsular fracture of the neck, and have received the name of *retinacula.* The capsule receives strengthening bands from the tendons of the rectus, ilio-psoas, gluteus minimus, and obturator externus.

The **ilio-femoral ligament** is the chief accessory band of the capsule. It is placed anteriorly, and is connected above with the ilium immediately below and behind the anterior inferior spine; it is attached below to the front of the great trochanter and spiral line as far as the inner border of the shaft of the femur. The fibres at the inner and outer borders of this ligament are thicker than the middle ones, and as they diverge from each other they present the appearance of an inverted Y, hence this ligament has been described by Bigelow under the name of the Y-shaped ligament; it must, however, be borne in mind that the interspace between the two limbs is filled in by radiating fibres, so that strictly no true Y-shaped ligament exists. Other accessory bands of fibres exist on the superior, inferior, and anterior aspects of the capsule; these have been named respectively, *ilio-trochanteric*, *ischio-capsular*, and *pubo-femoral* ligaments.

The **ligamentum teres** (fig. 159, 7), triangular in shape, is attached by a round apex to the depression just below the middle of the head of the femur, and by its base, which separates into two fasciculi, into the borders of the notch of the acetabulum, where it is connected with the transverse ligament. It is formed by a fasciculus of fibres of variable size, surrounded by synovial membrane; sometimes the synovial membrane is present without the fibres, or the ligament is wholly absent. The round ligament limits adduction in the flexed position, and thus resists dislocation of the head of the femur on to the dorsum of the ilium; it also limits external rotation when the limb is partly flexed.

The **cotyloid ligament** (fig. 159, 6) is a prismoid cord of fibro-cartilage, attached around the margin of the acetabulum, and serving to deepen that cavity and protect its edges. It is thicker at the upper and posterior border of the acetabulum than in front, is inclined inwards towards the acetabulum, and consists of fibres which arise from the whole circumference of the brim, and interlace with each other at acute angles.

The **transverse ligament** is a strong fasciculus of ligamentous fibres, continuous with the cotyloid ligament, and stretching across the notch of the acetabulum. It converts the notch into a foramen, through which the articular branches of the internal circumflex and obturator artery enter the joint.

The fossa at the bottom of the acetabulum is filled with a mass of fat, covered by synovial membrane, which serves as an elastic cushion for the head of the bone during its movements. This was described by Havers as the synovial gland.

The **synovial membrane** is extensive; it commences at the margin of the head of the femur, and is continued around the liga-

mentum teres to the acetabulum, whence it is reflected on the inner surface of the capsular ligament back to the head of the bone.

Capsular Muscles.—The muscles immediately surrounding and in contact with the hip-joint are—*in front*, psoas and iliacus, separated from the capsular ligament by a large synovial bursa; *above*, short head of the rectus and gluteus minimus; *behind*, pyriformis, gemellus superior, obturator internus, gemellus inferior, and quadratus femoris; and at the *inner side*, obturator externus and pectineus.

Actions.—The movements of the hip-joint are very extensive; they are *flexion*, *extension*, *adduction*, *abduction*, *circumduction*, and *rotation*. With regard to the hip-joint it is to be observed that the movements of the head of the femur in the acetabulum must be named differently from the consequent movements of the whole limb. Thus during flexion and extension of the thigh on the pelvis, the head of the femur is rotating in the acetabulum. Again, when the limb is being rotated inwards or outwards, the neck of the femur is performing angular movements with reference to the axis of the hip-joint. This depends on the position of the acetabulum and obliquity of the neck of the femur in relation to the shaft.

Bursæ.—Nine bursæ are found in the neighbourhood of the hip-joint, five in front and four behind. Those on the front are as follows:—One of large size between the ilio-psoas tendon and the capsule, which often communicates with the cavity of the joint; another between the tendon of the gluteus medius and the great trochanter; a third between the gluteus minimus and the great trochanter; a fourth between the gluteus maximus and vastus externus; and a fifth of large size and often multilocular between the gluteus maximus and great trochanter. The bursæ situated at the back of the joint are:—One beneath the tendon of the obturator externus, another between the quadratus femoris and great trochanter, a third between the capsule and common tendon of the obturator internus and gemelli, and a fifth between the quadratus femoris, obturator externus, and the back part of the capsule.

2. **KNEE-JOINT.**—The knee is a ginglymoid articulation of large size, and provided with numerous ligaments; the latter are fourteen in number, namely:—

Anterior or ligamentum patellæ,
Posterior or ligamentum posticum Winslowii,
Internal lateral,
Two external lateral,
Capsular ligament,
Anterior or external crucial,
Posterior or internal crucial,
Transverse,
Two coronary,
Ligamentum mucosum, } *false ligaments.*
Ligamenta alaria, }
Two semilunar fibro-cartilages,
Synovial membrane.

The first *six* are *external* to the articulation; the next *five* are *internal;* the remaining three are mere folds of synovial membrane, and have no title to the name of ligaments. In addition to the ligaments, there are two fibro-cartilages and a synovial membrane.

The **anterior ligament,** or **ligamentum patellæ,** is the prolongation of the tendon of the extensor muscles of the thigh downwards to the tubercle of the tibia. It is, therefore, no ligament; and, as the patella is simply a sesamoid bone developed in the tendon of the extensor muscles for the defence of the front of the knee-joint, the ligamentum patellæ has no title to consideration, either as a ligament of the knee-joint or as a ligament of the patella.

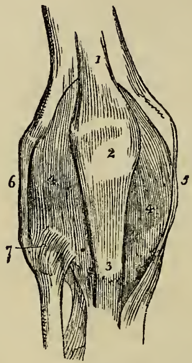


FIG. 169.—Anterior view of the ligaments of the knee-joint. 1. Tendon of the quadriceps extensor muscle of the leg. 2. Patella. 3. Anterior ligament, or ligamentum patellæ, near its insertion. 4,4. Synovial membrane. 5. Internal lateral ligament. 6. Long external lateral ligament. 7. Antero-superior tibio-fibular ligament.

The **posterior ligament,** or **ligamentum posticum Winslowii,** is a broad expansion of ligamentous fibres, which covers the whole of the posterior aspect of the joint. It is divisible into two lateral portions, which invest the condyles of the femur, and a central portion which is depressed, and formed by the interlacement of fasciculi passing in different directions. The strongest of these fasciculi is derived from the tendon of the semi-membranosus, and passes obliquely upwards and outwards from the posterior part of the inner tuberosity of the tibia to the external condyle of the femur. Other accessory fasciculi are given off by the tendon of the popliteus and heads of the gastrocnemius. The middle portion of the ligament supports the popliteal artery and vein, and is perforated by several openings for the passage of branches of the azygos articular artery and the nerves of the joint.

The **internal lateral ligament** is a broad and trapezoid layer of ligamentous fibres, attached above to the tubercle on the internal condyle of the femur, and below to the inner tuberosity and upper part of the shaft of the tibia. It is intimately connected with the edge of the internal semilunar cartilage and with the coronary ligament, and by its posterior edge becomes blended with the ligament of Winslow. It is crossed at its lower part by the tendons of the sartorius, gracilis, and semi-tendinosus, from which it is separated by a synovial bursa, and has passing beneath it the anterior slip of the semi-membranosus tendon and the inferior internal articular artery.

External lateral ligaments.—The **long** external lateral ligament

is a strong and round cord, which descends from the posterior part of the tubercle on the external condyle of the femur to the outer part of the head of the fibula.

The **short** external lateral ligament is an irregular fasciculus situated behind the preceding, arising from the external condyle near the origin of the head of the gastrocnemius muscle, and inserted into the middle of the outer surface of the head of the fibula. It is firmly connected with the external semilunar fibro-cartilage, and appears principally intended to connect that cartilage with the fibula: sometimes it is lost superiorly in the capsular ligament without reaching the femur.

The long external ligament is covered in by the tendon of the biceps, and has passing beneath it the tendon of origin of the popliteus muscle, and the inferior external articular artery.

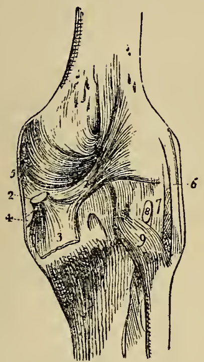


FIG. 170.—Posterior view of the ligaments of the knee-joint. 1. Fasciculus of the ligamentum posticum Winslowii, derived from (2) the tendon of the semi-membranosus muscle; the latter is cut through. 3. The process of the tendon which spreads out in the fascia of the popliteus muscle. 4. The process which is sent forwards beneath the internal lateral ligament. 5. Posterior border of the internal lateral ligament. 6. Long external lateral ligament. 7. Short external lateral ligament. 8. Tendon of the popliteus muscle cut through. 9. Postero-superior tibio-fibular ligament.

The **capsular ligament** consists of thin fibres which fill up the interval left between the patella in the centre and the lateral ligaments on each side; the fibres are attached above to the margin of the articular surface of the femur, and to the upper edge and lateral margins of the patella, while they are inserted below into the inner and outer tuberosities of the tibia. They are intimately connected with the lateral expansions of the tendons of the vastus externus, vastus internus, and crureus, and receive additional fibres from the tendons of the biceps, semi-tendinosus, and sartorius.

The true ligaments *within the joint* are the crucial, transverse, and coronary.

The **anterior** or **external crucial ligament** arises from the depression on the head of the tibia in front of the spinous process, and passes upwards and backwards to be inserted into the inner surface of the outer condyle of the femur, as far back as its posterior border. It is smaller than the posterior.

The **posterior** or **internal crucial ligament** arises from the depression on the head of the tibia behind the spinous process, and passes upwards and forwards to be inserted into the intercondylar hollow, and outer surface of the inner condyle of the femur. This ligament is less oblique and larger than the anterior. The anterior crucial ligament limits extension, and the posterior limits flexion; they also limit rotation when the leg is flexed.

The **transverse ligament** is a small slip of fibres which extends transversely from the external semilunar fibro-cartilage, near its anterior extremity, to the anterior convexity of the internal cartilage.

The **coronary ligaments** are the short fibres by which the convex borders of the semilunar cartilages are connected to the head of the tibia and ligaments surrounding the joint.

The **semilunar fibro-cartilages** are two falciform plates of fibro-cartilage, situated on the head of the tibia around its margin, and serving to deepen the surface of articulation for the condyles of the femur. They are thick along their convex border; thin and sharp along their concave edge.

The **internal semilunar fibro-cartilage** forms an oval cup for the reception of the internal condyle of the femur: it is connected by its convex border with the head of the tibia and internal and posterior ligaments, by means of its coronary ligament; and by its two extremities is firmly implanted into the depression before and behind the spinous process. The **external semilunar fibro-cartilage** bounds a circular fossa for the external condyle; it is connected by its convex border with the head of the tibia, and to the external and posterior ligaments by its coronary ligament; by its two extremities it is inserted into the depression between the two projections which constitute the spinous process of the tibia. The two extremities of the external cartilage, being inserted into the same fossa, form an almost complete circle, and the cartilage, being somewhat broader than the internal, nearly covers the articular surface of the tibia.

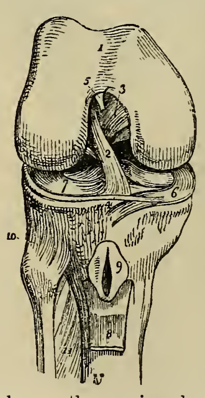


FIG. 171.—The right knee-joint laid open from the front in order to show the internal ligaments. 1. Cartilaginous surface of the lower extremity of the femur with its two condyles; the figure 5 rests on the external, the figure 3 on the internal, condyle. 2. Anterior crucial ligament. 3. Posterior crucial ligament. 4. Transverse ligament. 5. Attachment of the ligamentum mucosum; the rest has been removed. 6. Internal semilunar fibro-cartilage. 7. External fibro-cartilage. 8. Part of the ligamentum patellæ turned down. 9. Bursa situated between the ligamentum patellæ and the head of the tibia, laid open. 10. Antero-superior tibio-fibular ligament. 11. Interosseous membrane; the opening above this membrane is for the passage of the anterior tibial artery.

The external semilunar fibro-cartilage, besides giving off a fasciculus from its anterior border to constitute the transverse ligament, is continuous by some of its fibres with the extremity of the anterior crucial ligament: posteriorly it divides into three slips; one, a strong cord, ascends obliquely forwards to be inserted into the anterior part of the inner condyle of the femur in front of the posterior crucial ligament; another is the fasciculus of insertion into the fossa of the spinous process; while the third, of small size,

is continuous with the posterior part of the anterior crucial ligament.

The **ligamentum mucosum** is a slender conical process of synovial membrane enclosing a few ligamentous fibres which proceed from the transverse ligament. It is connected, by its apex, with the anterior part of the condylar notch, and, by its base, is lost in the mass of fat which projects into the joint beneath the patella.

The **alar ligaments** are two fringed folds of synovial membrane, extending from the ligamentum mucosum, along the edges of the mass of fat to the sides of the patella.

The **synovial membrane** of the knee-joint is by far the most extensive in the body. It commences near the margins of the cartilaginous surfaces of the condyles of the femur, it covers both surfaces of the semilunar fibro-cartilages, and is reflected upon the crucial ligaments, and inner surface of the ligaments which form the circumference of the joint. On each side of the patella it lines the capsular

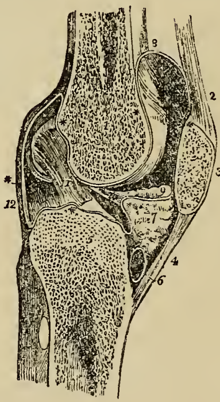


Fig. 172.—Longitudinal section of the left knee-joint, showing the reflections of its synovial membrane. 1. Cancellous structure of the lower part of the femur. 2. Tendon of the extensor muscles of the leg. 3. Patella. 4. Ligamentum patellæ. 5. Cancellous structure of the head of the tibia. 6. A bursa situated between the ligamentum patellæ and head of the tibia. 7. Mass of fat projecting into the cavity of the joint below the patella. ** The synovial membrane. 8. The pouch of synovial membrane which ascends between the tendon of the extensor muscles of the leg, and front of the lower extremity of the femur. 9. One of the alar ligaments; the other has been removed with the opposite section. 10. Ligamentum mucosum left entire; the section being made to its inner side. 11. Anterior or external crucial ligament. 12. Posterior ligament.

ligament, and forms a pouch of considerable size between the extensor tendon and front of the femur. It also forms the folds in the interior of the joint, called "ligamentum mucosum," and "ligamenta alaria." The superior pouch of the synovial membrane is supported and raised during the movements of the limb by a small muscle, the *subcrureus*, which is inserted into it.

Between the ligamentum patellæ and synovial membrane is a considerable mass of fat, which presses the membrane towards the interior of the joint, and occupies the fossa between the condyles.

Actions.—The knee-joint is one of the strongest of the articulations of the body, while, at the same time, it admits of the most perfect degree of movement in the direction of *flexion* and *extension*. During *flexion* the articular surface of the tibia glides forward on

the condyles of the femur; the lateral ligaments, the posterior ligament, and the anterior crucial ligament are relaxed; while the ligamentum patellæ being on the stretch, serves to press the adipose mass behind it into the vacuity formed in the front of the joint. In complete flexion the posterior crucial ligament is rendered tense, but flexion is also limited during life by the contact of the leg with the thigh. In complete *extension* all the ligaments are put on the stretch, with the exception of the ligamentum patellæ and the posterior crucial ligament. When the knee is semi-flexed, a partial degree of *rotation* is permitted.

Bursæ.—The bursæ in the neighbourhood of the knee-joint are numerous and important; three large ones are placed in front, and numerous small ones at the back of the joint. Those in front are—first, one, large and superficial, placed between the patella and subcutaneous tissue, it is this which becomes enlarged in the disease known as "housemaid's knee"; second, one between the common extensor tendon and the lower part of the shaft of the femur, it frequently communicates with the synovial pouch of the joint; the third is placed between the ligamentum patellæ and the head of the tibia; it also, sometimes, communicates with the cavity of the joint. The bursæ at the back of the joint are chiefly connected with the tendons of muscles; the most important are the following:—One placed between the tendons of the semi-membranosus and inner head of the gastrocnemius and the internal condyle; this is the largest bursa in the popliteal region, and extends from the posterior inferior part of the internal condyle to the back of the inner tuberosity of the tibia as low down as the upper border of the popliteus muscle. A second bursa lies between the anterior surface of the semi-membranosus tendon and the inner tuberosity of the tibia. Other bursæ exist, between the tendon of the popliteus and the external lateral ligament, between the same tendon and the outer tuberosity of the tibia, between the tendon of the biceps and the external lateral ligament, and beneath the outer head of the gastrocnemius.

3. **ARTICULATION BETWEEN THE TIBIA AND FIBULA.**—The tibia and fibula are held firmly connected by means of *seven* ligaments, namely:—

Anterior, } above. Posterior, }	Anterior, } below. Posterior, }
Interosseous membrane, Interosseous inferior,	Transverse.

The **anterior superior tibio-fibular ligament** is a strong fasciculus of parallel fibres passing obliquely downwards and outwards from the outer tuberosity of the tibia to the anterior surface of the head of the fibula.

The **posterior superior tibio-fibular ligament**, thicker and stronger than the anterior, is disposed in a similar manner on the

posterior surface of the joint. It is covered by the tendon of the popliteus.

Within the articulation there is a **synovial membrane** which is sometimes continuous with that of the knee-joint.

The **interosseous membrane** is a broad layer of aponeurotic fibres which pass obliquely downwards and outwards, from the sharp ridge on the tibia to the inner edge of the fibula, and are crossed at an acute angle by a few fibres taking the opposite direction. The ligament is deficient *above*, leaving a considerable interval between the bones, through which the anterior tibial artery takes its course forward to the anterior aspect of the leg; and perforated *below*, near its lower third, for the anterior peroneal artery and vein.

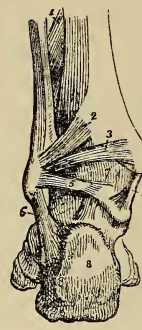


FIG. 173.—Posterior view of the ankle-joint. 1. Lower part of the interosseous membrane. 2. Postero-inferior ligament connecting the tibia and fibula. 3. Transverse ligament. 4. Internal lateral ligament. 5. Posterior fasciculus of the external lateral ligament. 6. Middle fasciculus of the external lateral ligament. 7. Synovial membrane of the ankle-joint. 8. Posterior tuberosity of the os calcis.

The interosseous membrane is *in relation*, *in front*, with the tibialis anticus, extensor longus digitorum, extensor proprius pollicis, anterior tibial vessels and nerve, and anterior peroneal artery; *behind*, with the tibialis posticus, flexor longus pollicis, flexor longus digitorum, and posterior peroneal artery.

The **inferior interosseous ligament** consists of short and strong fibres, which hold the bones firmly together inferiorly, where they are nearly in contact; it is continuous above with the interosseous membrane. This articulation is so firm, that the fibula is broken when an attempt is made to rupture the ligament.

The **anterior inferior tibio-fibular ligament** is a broad band, consisting of two fasciculi of parallel fibres which pass obliquely across the anterior aspect of the articulation of the two bones at their inferior extremity, from tibia to fibula.

The **posterior inferior tibio-fibular ligament** is a similar band on the posterior surface of the articulation. Both ligaments project somewhat below the margin of the bones, and serve to deepen the cavity of articulation with the astragalus.

The **transverse ligament** is a narrow band of ligamentous fibres, continuous with the preceding, and passing transversely across the back of the ankle-joint between the two malleoli.

The **synovial membrane** of the inferior tibio-fibular articulation is a duplicature of the synovial membrane of the ankle-joint, reflected upwards for a short distance between the two bones.

Actions.—Between the tibia and fibula there exists a slight degree of movement, which is calculated to enable the latter to resist injury by yielding for a trifling extent to forcible pressure.

4. **ANKLE-JOINT.**—The ankle is a ginglymoid articulation; the surfaces entering into its formation are the under surface of the tibia with its malleolus and the malleolus of the fibula, above; and the surface of the astragalus with its two lateral facets, below. The ligaments are four in number:—

Anterior,	External lateral,
Internal lateral,	Posterior.

The **anterior ligament** is a thin membranous layer, passing from the margin of the tibia to the astragalus in front of its articular surface. It is *in relation, in front,* with the tendons of the extensors of the great and lesser toes, tibialis anticus, peroneus tertius, and anterior tibial vessels and nerves. *Posteriorly* it lies in contact with a stratum of extra-synovial adipose tissue and the synovial membrane.

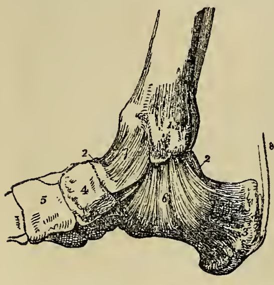


FIG. 174.—Internal view of the ankle-joint. 1. Internal malleolus of the tibia. 2, 2. Astragalus. 3. Os calcis. 4. Scaphoid bone. 5. Internal cuneiform bone. 6. Internal lateral or deltoid ligament. 7. Anterior ligament. 8. Tendo Achillis; a small bursa is seen interposed between this tendon and the posterior tuberosity of the os calcis.

The **internal lateral** or **deltoid ligament** is a triangular layer of fibres, attached superiorly, by its apex, to the internal malleolus; inferiorly, by an expanded base, to the astragalus, os calcis, and scaphoid bones. Beneath the superficial layer of this ligament is a stronger and thicker fasciculus, which connects the apex of the internal malleolus with the side of the astragalus.

The internal lateral ligament is covered in and partly concealed by the tendon of the tibialis posticus, and, at its posterior part, is in relation with the tendon of the flexor longus digitorum and flexor longus pollicis.

The **external lateral ligament** consists of three strong fasciculi, which proceed from the inner side of the external malleolus, and radiate in three different directions. The *anterior fasciculus* passes forward, to be attached to the astragalus; the *posterior*, backward, to be connected with the astragalus posteriorly; and the *middle*, longer than the other two, descends to be inserted into the outer side of the os calcis.

In addition to the transverse ligament of the inferior tibio-fibular articulation, there are also found at the back of the ankle a few fibres having chiefly a vertical direction, which have been described as the **posterior ligament** of this joint. They are attached above to the external malleolus, the back part of the lower end of the tibia, and to the posterior inferior tibio-fibular ligament, and below to the posterior surface of the astragalus, from the external to the internal lateral ligaments.

The **synovial membrane** is reflected upon the anterior and lateral ligaments, and on the transverse and posterior ligaments behind; it also sends a fold upwards between the tibia and fibula.

Actions.—The movements are mainly those of *flexion* and *extension*, the latter being accompanied by a slight inward movement of the toes, in consequence of the outer border of the articular surface of the astragalus being longer than the inner. Both the cupped lower end of the tibia and the corresponding surface of the astragalus are wider in front than behind, hence, in complete extension the narrow part of the latter comes to occupy the wide part of the former, and a limited degree of lateral motion is thus allowed; in flexion, on the other hand, they fit accurately to each other, thus securing that fixation so necessary to the erect posture.

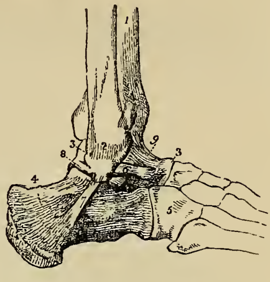


FIG. 175.—External view of the ankle joint. 1. Tibia. 2. External malleolus of the fibula. 3, 3. Astragalus. 4. Os calcis. 5. Cuboid bone. 6. Anterior fasciculus of the external lateral ligament attached to the astragalus. 7. Its middle fasciculus, attached to the os calcis. 8. Its posterior fasciculus, attached to the astragalus. 9. Anterior ligament of the ankle.

Bursæ.—The bursæ in connection with the ankle-joint are chiefly of the ensheathing or vaginal variety, and are continued for some distance along the tendons on the front and back of the joint. The annular ligament binding down the tendons in front of the joint is divided into three compartments, each of which has its special synovial sheath. The first gives passage to the tibialis anticus, the second to the extensor longus pollicis, and the third is common to the extensor longus digitorum and peroneus tertius. Behind the ankle there is a bursa common to the two peronei muscles, one in the course of the flexor longus digitorum, and one in that of the tibialis posticus.

5. **ARTICULATION OF THE TARSAL BONES.**—The ligaments which connect the seven bones of the tarsus to each other are of three kinds:—

Dorsal, Plantar, Interosseous.

The **dorsal ligaments** are small fasciculi of parallel fibres, which pass from each bone to all the neighbouring bones with which it articulates. The only dorsal ligaments deserving of particular mention are the **external** and **posterior astragalo-calcaneal**, which, with the interosseous ligament, complete the articulation of the astragalus with the os calcis; the **superior** and **internal calcaneo-cuboid** ligaments; and the **superior astragalo-scaphoid** ligament. The internal calcaneo-cuboid, and superior calcaneo-scaphoid ligament, which are closely united posteriorly in the deep groove which intervenes between the astragalus and os calcis, separate anteriorly to

reach their respective bones; they form the principal bond of connection between the first and second range of bones of the foot. It is the division of this portion of these ligaments that demands the careful attention of the surgeon in performing Chopart's operation.

The **plantar ligaments** have the same disposition on the plantar surface of the foot; three of them, however, are of large size, and have especial names, viz., the

Calcaneo-scaphoid,
Long calcaneo-cuboid,
Short calcaneo-cuboid.

The **inferior calcaneo-scaphoid ligament** is a broad and fibro-cartilaginous band of ligament which passes forward from the anterior and inner border of the os calcis to the edge of the scaphoid bone. Besides connecting the os calcis and scaphoid, it supports the astragalus, and forms part of the cavity in which the rounded head of the latter bone is received. It is lined on its upper surface by the synovial membrane of the astragalo-scaphoid articulation.

FIG. 176.—Ligaments of the sole of the foot. 1. Os calcis. 2. Astralagus. 3. Tuberosity of the scaphoid bone. 4. Long calcaneo-cuboid ligament. 5. Part of the short calcaneo-cuboid ligament. 6. Calcaneo-scaphoid ligament. 7. Plantar tarsal ligaments. 8, 8. Tendon of the peroneus longus muscle. 9, 9. Plantar tarso-metatarsal ligaments. 10. Plantar ligament of the metatarso-phalangeal articulation of the great toe; the same ligament is seen on the other toes. 11. Lateral ligaments of the metatarsal - phalangeal articulation. 12. Transverse ligament. 13. Lateral ligaments of the phalanges of the great toe; the same ligaments are seen on the other toes.

The firm connection of the os calcis with the scaphoid bone, and the feebleness of the astragalo-scaphoid articulation, are conditions favourable to the occasional dislocation of the head of the astragalus.

The **long calcaneo-cuboid ligament** or **ligamentum longum plantæ** is a long band of ligamentous fibres which proceeds from the under surface of the os calcis to the rough surface on the under part of the cuboid bone, its fibres being continued onwards to the base of the third and fourth metatarsal bones.

This ligament forms the inferior boundary of the canal in the cuboid bone, through which the tendon of the peroneus longus passes to its insertion into the base of the metatarsal bone of the great toe.

The **short calcaneo-cuboid** or **ligamentum breve plantæ** is situated closer to the bones than the long plantar ligament, from

which it is separated by adipose tissue; it is broad and extensive, and ties the under part of the os calcis and cuboid bone firmly together.

The **interosseous ligaments** are five in number; they are short and strong ligamentous fibres situated between adjoining bones,

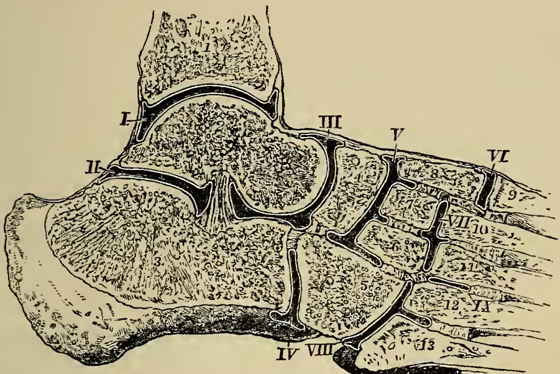


Fig. 177.—Diagram showing the arrangement of the synovial membranes of the tarsal joints. I. Synovial membrane between the tibia and astragalus. II. That between the back of the astragalus and os calcis. III. That between the astragalus and scaphoid, and between the front of the astragalus and os calcis. IV. Between the os calcis and cuboid. V. Between the cuneiform bones and scaphoid. VI. Between the internal cuneiform and metatarsal of big toe. VII. Between the middle metatarsal and two outer cuneiform bones. VIII. Between the cuboid and outer metatarsals. IX. Between the third and fourth metatarsals. 1. Tibia. 2. Astragalus. 3. Os calcis. 4. Scaphoid. 5. Cuboid. 6. External cuneiform. 7. Middle, and 8, Internal cuneiform. 9, 10, 11, 12, 13. Metatarsal bones. Interosseous ligaments are shown connecting the several bones of the tarsus and metatarsus.

and firmly attached to their rough surfaces. One of these, **astragalo-calcaneal**, is lodged in the groove between the upper surface of the os calcis and the lower of the astragalus. It is large and very strong, consists of vertical and oblique fibres, and serves to unite the os calcis and astragalus solidly together. The second interosseous ligament, also very strong, is situated between the sides of the scaphoid and cuboid bone; the three remaining interosseous ligaments connect strongly together the three cuneiform bones and the cuboid.

The **synovial membranes** of the tarsus are four in number: *one*, for the posterior astragalo-calcaneal articulation; a *second*, for the anterior astragalo-calcaneal and astragalo-scaphoid articulation; occasionally an additional small synovial membrane is found in the anterior astragalo-calcaneal joint; a *third*, for the calcaneo-cuboid articulation; and a *fourth*, the large tarsal synovial membrane for the articulations between the scaphoid and three cuneiform bones, the cuneiform bones with each other, the external cuneiform bone with the cuboid, and the two outer cuneiform bones with the

bases of the second and third metatarsal bones. The prolongation which reaches the metatarsal bones passes forward between the internal and middle cuneiform bone. The synovial membrane between the two outer cuneiform and second and third metatarsal bones is often distinct from the large one; it is so represented in fig. 177, VII. A small synovial membrane is sometimes met with between the contiguous surfaces of the scaphoid and cuboid bone.

Actions.—The movements permitted by the articulation between the astragalus and os calcis, are a slight degree of gliding, in the direction *forwards* and *backwards*, and *laterally* from side to side. The movements of the second range of tarsal bones are very trifling, being greater between the scaphoid and three cuneiform bones than in the other articulations. The movements occurring between the first and second range are the most considerable; they are *adduction* and *abduction*; and, in a minor degree, *flexion*, which increases the arch of the foot, and *extension*, which flattens the arch.

6. **TARSO-METATARSAL ARTICULATION.**—The ligaments of this articulation are :—

Dorsal. Plantar, Interosseous.

The **dorsal ligaments** connect the metatarsal to the tarsal bones, and the metatarsal bones with each other. The base of the second metatarsal bone, articulating with the three cuneiform bones, receives a ligamentous slip from each, while the rest articulating with a single tarsal bone receive only a single tarsal slip.

The **plantar ligaments** have a similar disposition on the plantar surface.

The **interosseous ligaments** are situated between the bases of the metatarsal bones of the four lesser toes; also between the base of the second and third metatarsal bones and the internal and external cuneiform bones.

The metatarsal bone of the second toe being implanted by its base between the internal and external cuneiform bones, is the most strongly articulated of all the metatarsal bones. This disposition must be recollected in amputation at the tarso-metatarsal articulation.

The **synovial membranes** of the tarso-metatarsal articulation are three in number: one for the metatarsal bone of the great toe; one for the second and third metatarsal bones, which is continuous with the great tarsal synovial membrane; and one for the fourth and fifth metatarsal bones.

Actions.—The movements of the metatarsal on the tarsal bones and on each other are very slight; they are such only as contribute to the strength of the foot, by permitting a certain degree of yielding to opposing forces.

7. **METATARSO-PHALANGEAL ARTICULATION.**—The ligaments of this articulation, like those between the first phalanges and metacarpal bones of the hand, are :—

Inferior or plantar, Two lateral, Transverse.

The **inferior** or **plantar ligaments**, thick and fibro-cartilaginous, form part of the articulating surface of the joint.

The **lateral ligaments**, short and very strong, are situated one on each side of the joint.

The **transverse ligament** is a strong band, which passes transversely between the plantar ligaments.

The expansion of the extensor tendon supplies the place of a dorsal ligament.

Actions.—The movements of the first phalanges on the rounded heads of the metatarsal bones are *flexion*, *extension*, *adduction*, and *abduction.*

8. **ARTICULATION OF THE PHALANGES.**—The ligaments of the phalanges are the same as those of the fingers, and have the same disposition; their actions are also similar. They are :—

Inferior or plantar, and, Two lateral.

PART IV.

MYOLOGY.

In this section will be described the arrangement, attachments, and actions of the voluntary muscles, and the disposition of the fasciæ supporting or connected with them.

MUSCLES present various modifications in the arrangement of their fibres in relation to their tendinous structure. Sometimes they are longitudinal, and terminate at each extremity in tendon, the entire muscle being *fusiform* in shape; in other situations they are disposed like the rays of a fan, converging to a tendinous point, as the temporal, pectoral, glutei, &c., and constitute a *radiate* muscle. Again, they are *penniform*, converging like the barbs of a feather to one side of a tendon, which runs the whole length of the muscle, as in the peronei; or *bipenniform*, converging to both sides of the tendon. In other muscles the fibres pass obliquely from the surface of a tendinous expansion spread out on one side, to that of another extended on the opposite side, as in the semi-membranosus; or, they are composed of penniform or bipenniform fasciculi, as in the deltoid, and constitute a compound muscle. In the broad muscle the tendon is spread out so as to form an expansion, called *aponeurosis.*

The nomenclature of muscles is defective and confused, and is generally derived from some prominent character which the muscle presents; thus, some are named from their situation, as the tibialis, peroneus, brachialis, temporal; others from their use, as the flexors, extensors, adductors, abductors, levators, tensors, sphincters, &c. Some again from their form, as the trapezius, triangularis, deltoid, rhomboid, scalene, orbicularis, &c.; and others from their direction, as the rectus, obliquus, transversalis, &c. Certain muscles have received names expressive of their attachments, as the sterno-mastoid, sterno-hyoid, &c.; and others, of their divisions, as the biceps, triceps, digastricus, complexus, &c.

In the description of a muscle we express its attachment by the words "origin" and "insertion:" the term *origin* is generally applied to the more fixed or central attachment, or to the point towards which the motion is directed, while *insertion* is assigned to

the more movable point, or to that most distant from the centre; but there are exceptions to this principle, and as many muscles pull equally towards both extremities, the use of such terms must be regarded as arbitrary.

FASCIA (fascia, a bandage) is the name assigned to fibrous laminæ of various extent and thickness, which are distributed through the different regions of the body, for the purpose of investing or protecting the softer and more delicate organs. From a consideration of their structure, these fasciæ may be arranged into two groups: areolo-fibrous fasciæ, and aponeurotic fasciæ.

The **areolo-fibrous fascia** is best illustrated by the common subcutaneous investment of the entire body, the superficial fascia. This structure is situated immediately beneath the integument over every part of the frame, and is the medium of connection between that layer and the deeper parts. It is composed of areolar and elastic tissue, and contains in its areolæ an abundance of adipose tissue, constituting the *panniculus adiposus.* The fat being a bad conductor of heat serves to retain the warmth of the body; while it forms at the same time a yielding tissue, through which minute vessels and nerves pass to the skin, without incurring the risk of obstruction from injury or pressure. Fat is, however, absent from the subcutaneous tissue of the penis, scrotum, and eyelids. By dissection, the superficial fascia may be separated into *two layers*, between which are found the superficial or cutaneous vessels and nerves; as the superficial epigastric artery, saphena veins, radial and ulnar veins, superficial lymphatic vessels, and the cutaneous muscles, such as the platysma myoides. The deep layer of this fascia usually forms a more distinct sheet than the superficial, and is almost devoid of fat vesicles.

The **aponeurotic** or **deep fascia** is the strongest kind of investing membrane; it is composed of tendinous fibres, running parallel with each other, and connected by other fibres of the same kind passing in different directions, together with areolar tissue and fine elastic fibres. When freshly exposed, it is white, glistening, and iridescent, and is firm, unyielding, and but little elastic. It encloses and forms distinct sheaths to all the muscles and tendons. It is thick on the outer and least protected side of the limb, and thinner at its inner side. It is firmly connected to the bones, and to the prominent points of each region, as to the pelvis, knee, and ankle, in the lower; and to the clavicle, scapula, elbow, and wrist, in the upper extremity. It assists the muscles in their action, by keeping up a tonic pressure on their surface; aids materially in the circulation of the fluids; and in the palm of the hand and sole of the foot is a powerful protection to the structures which enter into the composition of those regions. In some situations its tension is regulated by muscular action, as by the tensor vaginæ femoris and gluteus maximus in the thigh, by the biceps in the leg, and by the biceps and palmaris longus in the arm; in other situations it affords an extensive surface for the origin of the fibres of muscles.

The MUSCLES and FASCIÆ may be arranged in conformity with the general division of the body into—1. Those of the head and neck. 2. Those of the trunk. 3. Those of the upper extremity. 4. Those of the lower extremity.

MUSCLES AND FASCIÆ OF THE HEAD AND NECK.

These admit of subdivision into those of the head and face, and those of the neck.

Muscles of the Head and Face.—These muscles may be divided into groups corresponding with the natural regions of the head and face; the groups are eight in number, namely:—

1. Cranial group.
2. Orbital group.
3. Auricular group.
4. Ocular group.
5. Nasal group.
6. Superior labial group.
7. Inferior labial group.
8. Maxillary group.

The muscles of each of these groups may be thus arranged:—

1. Cranial Group.

Occipito-frontalis.

2. Orbital Group.

Orbicularis palpebrarum,
Corrugator supercilii,
Tensor tarsi.

3. Auricular Group.

Attollens auriculam,
Attrahens auriculam,
Retrahens auriculam.

4. Ocular Group.

Levator palpebræ,
Rectus superior,
Rectus inferior,
Rectus internus,
Rectus externus,
Obliquus superior,
Obliquus inferior.

5. Nasal Group.

Pyramidalis nasi,
Compressor nasi,
Dilatator naris,
Depressor alæ nasi.

6. Superior Labial Group.

(Orbicularis oris),
Levator labii superioris alæque nasi,
Levator labii superioris proprius,
Levator anguli oris,
Zygomaticus major,
Zygomaticus minor.

7. Inferior Labial Group.

(Orbicularis oris),*
Depressor labii inferioris,
Depressor anguli oris,
Risorius Santorini,
Levator labii inferioris.

8. Maxillary Group.

Masseter,
Temporal,
Buccinator,
Pterygoideus externus,
Pterygoideus internus.

* The orbicularis oris, from encircling the mouth, belongs necessarily to both the superior and inferior labial region; it is therefore enclosed within parentheses.

1. **Cranial Group.**—Occipito-frontalis.

Dissection.—The *occipito-frontalis* is to be dissected by making a longitudinal incision along the vertex of the head, from the root of the nose to the external occipital protuberance, and a second incision along the forehead and around the side of the head, to join the two extremities of the preceding. Dissect the integument and superficial fascia carefully outwards, beginning at the anterior angle of the flap, where the muscular fibres are thickest, and remove it altogether. This dissection requires care; for the muscle is very thin, and without attention would be raised with the integument.

Fascia.—The **superficial fascia** forms a firm, dense layer, which is closely connected with the integument and the surface of the aponeurosis of the occipito-frontalis; behind it becomes continuous with the superficial fascia of the neck, and laterally it passes over the temporal aponeurosis, and may be traced nearly as far as the zygoma. It contains between its layers the muscles of the auricle, and the superficial vessels and nerves. There is no deep fascia on the face or head, nor is it required; for here the muscles are closely applied against the bones, upon which they depend for support, whilst in the extremities the support is derived from the dense layer of fascia by which they are invested, and which forms for each muscle a distinct sheath.

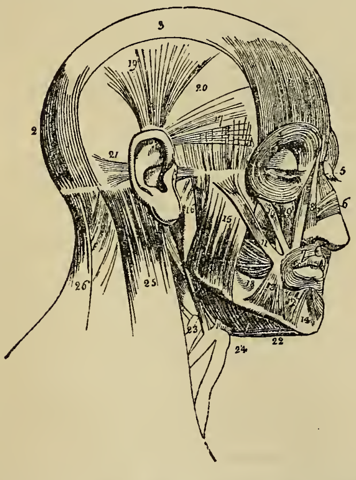


Fig. 178.—Muscles of the head and face. 1. Frontal portion of the occipito-frontalis. 2. Its occipital portion. 3. Its aponeurosis. 4. Orbicularis palpebrarum, which conceals the corrugator supercilii and tensor tarsi. 5. Pyramidalis nasi. 6. Compressor nasi. 7. Orbicularis oris. 8. Levator labii superioris alæque nasi; the adjoining fasciculus between figures 8 and 9 is the labial portion of the muscle. 9. Levator labii superioris proprius; the lower part of the levator anguli oris is seen between the muscles 10 and 11. 10. Zygomaticus minor. 11. Zygomaticus major. 12. Depressor labii inferioris. 13. Depressor anguli oris. 14. Levator labii inferioris. 15. Superficial portion of the masseter 16. Part of its deep portion. 17. Attrahens auriculam. 18. Buccinator. 19. Attollens auriculam. 20. Temporal fascia covering the temporal muscle. 21. Retrahens auriculam. 22. Anterior belly of the digastric; the tendon is seen passing through its aponeurotic pulley. 23. Stylo-hyoid muscle pierced by the posterior belly of the digastric. 24. Mylo-hyoid. 25. Upper part of the sterno-mastoid. 26. Upper part of the trapezius. The muscle between 25 and 26 is the splenius.

The **OCCIPITO-FRONTALIS** is a broad musculo-aponeurotic layer, which covers the whole side of the vertex of the skull,

from the occiput to the eyebrow. It consists of two fleshy bellies (often described as distinct muscles), and an intervening tendinous aponeurosis. The *occipital* portion *arises* from the outer two-thirds of the superior curved line of the occipital bone, and from the mastoid portion of the temporal; its fibres pass upwards to be inserted into the posterior margin of the aponeurosis. The *frontal* portion is thinner and paler than the occipital, but covers a larger extent of surface, its fibres are continuous with those of the pyramidalis nasi, corrugator supercilii, and orbicularis palpebrarum; immediately above the root of the nose the fibres of the right and left muscles are united, but as they pass upwards a small angular interval is left between them; they are inserted into the anterior extremity of the aponeurosis. Most of the frontal fibres have no bony attachment, but a few are connected with the internal angular process of the frontal bone. The *aponeurosis* of the two sides covers the whole of the vertex of the skull, and terminates in front and behind in narrow processes interposed between the fleshy bellies; it is attached posteriorly to the occipital protuberance and superior curved line, and receives in front the attachment of the anterior bellies, ending about the middle of the forehead. By its lateral margins it gives origin to the attollens and attrahens auriculam muscles, and is continued down to the zygoma as a thin layer of fascia.

Relations.—This muscle is in relation by its *external surface* with the frontal and supraorbital vessels, supraorbital and facial nerve, temporal vessels and auriculo-temporal nerve, occipital vessels and nerves, and integument, to which last it is closely adherent. Its *under surface* is attached to the pericranium by a loose cellular tissue, which permits considerable movement.

Nerve Supply.—Posterior or occipital portion by the posterior auricular; frontal portion by the temporal—both branches of the facial.

Actions.—The occipital portion acting alone draws the scalp backwards. The frontal portion, if it has its fixed point above, draws the eyebrows upwards and produces transverse wrinkles in the forehead, as in expressing surprise, wonder, attention, or terror; if its fixed point be below it draws forward the scalp. By the alternate action of the two portions the scalp is drawn to and fro on the underlying pericranium.

2. **Orbital Group.**—

Orbicularis palpebrarum, Corrugator supercilii,
Tensor tarsi.

Dissection.—Great care is requisite in the dissection of the first of these muscles, from the total absence of subcutaneous fat over the eyelids, and the extreme delicacy of the muscular fibres which cover them. A hook should be introduced into the palpebral fissure at the outer canthus, and one of the other hooks of the set fastened

to the table, so as to put the eyelids slightly on the stretch; an incision should be made along the margin of each lid, and the cut already made from the scalp to the root of the nose should be carried onwards to the tip of that organ. The skin is now to be raised from the margin of the lids as a delicate layer not thicker than ordinary tissue paper. In order completely to expose the orbicularis it will be necessary to make an additional incision, after the skin has been raised from the lids, from the outer canthus of the eye on to the lateral aspect of the head.

The **ORBICULARIS PALPEBRARUM** is a sphincter muscle, surrounding the orbit and eyelids, and consists of two portions, external and internal. The *external* or *orbital portion arises* from a short tendon, tendo oculi, situated at the inner angle of the eye, from the nasal process of the superior maxillary and internal angular process of the frontal bone; it encircles the orbit, and is *inserted* into the inner border of the orbit and lower border of the tendo oculi, some of its fibres being continuous with the upper segment. This portion of the muscle becomes intimately blended with the occipito-frontalis and corrugator supercilii; it also sends off slips which communicate with the muscles of the upper lip. The *internal portion* (palpebral) forms a curved plane of fibres on the eyelids, thinner and paler than the orbital portion; externally these fibres are attached to the external palpebral ligament and border of the orbit, some being continuous with the orbital portion; internally they are attached to the borders of the lacus lachrymalis and tendo oculi. The borders of the palpebral portion nearest the edges of the lids are thicker than the rest, and termed *ciliary*. The ciliary portion is redder than the rest of the palpebral, and is continuous with the tensor tarsi.

A few fibres placed within the line of the eyelashes and separated by them from the rest of the orbicularis, have been described as a distinct muscle under the name of *ciliary muscle of Riolan*.

The **tendo oculi**, about two lines in length and one in breadth, is attached by one end to the nasal process of the superior maxillary bone, close to the edge of the orbit; the other end bifurcates to be inserted into the inner extremities of the tarsal cartilages; from its inner side is given off a process which spreads over the lachrymal sac, and is attached to the crest of the lachrymal bone; this is the reflected aponeurosis of the tendo oculi, and serves to protect the lachrymal sac.

Relations. — By its *superficial surface* the muscle is closely adherent to the integument, from which it is separated on the eyelids by a loose cellular tissue. By its *deep surface* it lies in contact, *above*, with the upper border of the orbit, corrugator supercilii muscle, frontal and supraorbital vessels, and supraorbital nerve; *below*, with the lachrymal sac, levator labii superioris alæque nasi, levator labii superioris proprius, zygomaticus major and minor muscles, and malar bone; *externally*, with the temporal fascia. On the eyelids it is in relation with the broad tarsal ligament and tarsal

cartilages, and by its upper border is connected with the occipito-frontalis.

Nerve Supply.—Temporal and malar branches of the facial.

The **CORRUGATOR SUPERCILII** is a small, narrow, and pointed muscle, situated immediately above the orbit, and beneath the upper segment of the orbicularis palpebrarum. It *arises* from the inner extremity of the superciliary ridge, and is *inserted* into the under surface of the orbicularis palpebrarum. Its connection with the orbicularis commences near the supraorbital foramen, and is continued outwards to the middle of the orbital arch.

Relations.—By its *superficial surface*, with the pyramidalis nasi, occipito-frontalis and orbicularis palpebrarum; by its *deep surface*, with the supraorbital vessels and nerve.

Nerve Supply.—The facial nerve.

The **TENSOR TARSI** (Horner's muscle) is a thin plane of muscular fibres, about three lines in breadth and six in length. It is best dissected (after the dissection of the orbit has been completed) by separating the eyelids from the eye, and turning them over the nose without disturbing the tendo palpebrarum oculi; then dissect away the small fold of mucous membrane called plica semilunaris, and some loose cellular tissue under which the muscle is concealed. It *arises* from the orbital surface of the lachrymal bone, and passing across the lachrymal sac, divides into two slips, which are continuous with the margin of the orbicularis along the edges of the lids; some few of its fibres being attached to the lachrymal canals as far as the puncta. According to some anatomists the tensor tarsi is a process of the orbicularis, consisting of two small fasciculi which enclose the lachrymal canals, and then spread out on the aponeurosis of the lachrymal sac to be inserted into the crest and orbital surface of the lachrymal bone.

Nerve Supply.—Infraorbital branch of facial.

Actions.—The palpebral portion of the orbicularis acts involuntarily in closing the lids, and from the greater curve of the upper lid, upon that principally. The entire muscle constitutes a sphincter, drawing at the same time, by means of its osseous attachment, the integument and lids inwards towards the nose. The corrugatores superciliorum draw the eyebrows downwards and inwards, and produce the vertical wrinkles of the forehead. The *tensor tarsi*, or lachrymal muscle, is an auxiliary to the orbicularis, and draws the extremities of the lachrymal canals inwards, so as to place the puncta in the best position for receiving the tears. It compresses the lachrymal sac, and serves also to keep the lids in relation with the surface of the eye.

3. **Auricular Group.**—

Attollens auriculam, Attrahens auriculam,
Retrahens auriculam.

Dissection.—If the pinna of the ear be drawn down by means of a hook, a ridge of skin will rise up, extending from the ear to the

cut edge of the scalp ; along this ridge an incision is to be made and the skin reflected downwards ; by this means the upper of the three muscles will be exposed. In like manner the pinna must be drawn backwards to expose the attrahens, and forwards to expose the retrahens, the skin being removed by an incision close around the base of the ear, supplemented by others running in the course of the muscles. The muscles are best dissected by commencing with their tendons, and thence proceeding in the course of their radiating fibres.

The **ATTOLLENS AURICULAM**, the largest of the three, is a thin triangular plane of muscular fibres, *arising* from the lateral portion of the aponeurosis of the occipito-frontalis at about the middle of the temporal ridge, and *inserted* into the upper part of the concha and inner and upper part of the pinna.

It is **in relation** by its external surface with the integument, and by the internal with the temporal fascia.

It receives its nerve supply from the occipitalis minor nerve, with some filaments from the facial nerve.

The **ATTRAHENS AURICULAM**, also triangular, *arises* from the lateral portion of the aponeurosis of the occipito-frontalis above the zygoma, and is *inserted* into the spine of the helix. It is often blended with the anterior edge of the former muscle.

It is **in relation** by its external surface with the integument, and by the internal with the temporal fascia and temporal artery and veins.

It receives its nerve supply from filaments of the facial.

The **RETRAHENS AURICULAM** *arises* by two (sometimes three) muscular slips from the root of the mastoid process. They are *inserted* into the posterior surface of the concha.

It is **in relation** by its external surface with the integument, and by its internal surface with the mastoid portion of the temporal bone.

It is supplied by the posterior auricular branch of the facial nerve.

Actions.—The *actions* of the auricular muscles are expressed in their names ; they have but little power in man, but are important muscles in brutes.

4. **Ocular Group.**—

Levator palpebræ,	Rectus internus,
Rectus superior,	Rectus externus,
Rectus inferior,	Obliquus superior,
	Obliquus inferior.

Dissection.—To open the orbit (the calvarium and brain having been removed) the frontal bone must be sawn through at the inner extremity of the orbital ridge, the saw being directed to the supra-orbital notch ; and, externally, at its outer extremity. The roof of the orbit may then be comminuted with the hammer—a process easily accomplished, on account of the thinness of the orbital plate of the frontal bone and lesser wing of the sphenoid. The superciliary portion of the orbit may next be driven forwards by a smart

blow, and the external angular process and external wall of the orbit outwards in the same manner; the broken fragments of the roof of the orbit should then be removed. By this means the periosteum will be exposed unbroken and undisturbed. Remove the periosteum from the whole of the upper surface of the exposed orbit, and examine the parts beneath.

The **LEVATOR PALPEBRÆ** is a long, thin, and triangular muscle, situated in the upper part of the orbit on the middle line; it *arises* from the under surface of the lesser wing of the sphenoid, above and in front of the optic foramen, and is *inserted* into the upper border of the superior tarsal cartilage by a broad but thin tendon.

Relations.—By its *upper surface* with the fourth nerve, supra-orbital nerve and artery, periosteum of the orbit, and, in front, inner face of the broad tarsal ligament. By its *under surface* it rests on the superior rectus, globe of the eye, and conjunctiva; it receives its nerve and artery by this aspect.

Nerve Supply.—Superior division of the third nerve.

The **RECTUS SUPERIOR** (attollens) *arises* from the upper margin of the optic foramen, and from the fibrous sheath of the optic nerve; and is *inserted* into the upper surface of the globe of the eye at a point somewhat more than three lines from the margin of the cornea.

Relations.—By its *upper surface* with the levator palpebræ muscle; by the *under surface* with the optic nerve, ophthalmic artery and nasal nerve, from which it is separated by the adipose tissue of the orbit, and, in front, with the globe of the eye, the tendon of the superior oblique muscle being interposed.

Nerve Supply.—Superior division of the third nerve.

The **RECTUS INFERIOR** (depressor) *arises* from the inferior margin of the optic foramen by a tendon (ligament of Zinn) which is common to it and the internal and external rectus, and from the fibrous sheath of the optic nerve; it is *inserted* into the inferior surface of the globe of the eye, a little more than two lines from the margin of the cornea.

Relations.—By its *upper surface* with the optic nerve, inferior branch of the third nerve, adipose tissue of the orbit, and under surface of the globe of the eye. By its *under surface* with the periosteum of the floor of the orbit, and inferior oblique muscle.

Nerve Supply.—Inferior division of the third nerve.

The **RECTUS INTERNUS** (adductor), the thickest and shortest of the straight muscles, *arises* from the common tendon, and from the fibrous sheath of the optic nerve; and is *inserted* into the inner surface of the globe of the eye at two lines from the margin of the cornea.

Relations.—By its *internal surface* with the optic nerve, adipose tissue of the orbit and eyeball. By its *outer surface* with the periosteum of the orbit; by its *upper border* with the anterior and posterior ethmoidal vessels, nasal and infra-trochlear nerve.

Nerve Supply.—Inferior division of the third nerve.

The **RECTUS EXTERNUS** (abductor), the longest of the straight muscles, *arises* by two heads, one with the origin of the superior rectus, from the margin of the optic foramen, the other partly from the common tendon, and partly from the lower margin of the sphenoidal fissure; the nasal, third, and sixth nerves and ophthalmic vein passing between them. It is *inserted* into the outer surface of the globe of the eye, a little more than two lines from the margin of the cornea.

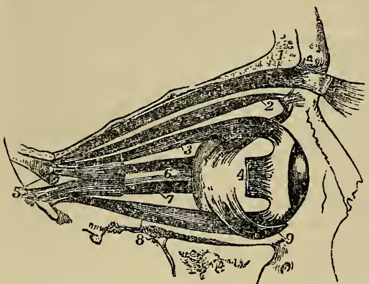


Fig. 179.—Muscles of the eyeball; the view is taken from the outer side of the right orbit. 1. Levator palpebræ. 2. Superior oblique. 3. Superior rectus. 4. Cut outer end of the external rectus. 5. The two heads of origin of the external rectus. 6. Optic nerve. 7. Internal rectus. 8. Inferior rectus. 9. Inferior oblique.

Relations.—By its *internal surface* with the third, nasal, sixth, and optic nerves, ciliary ganglion and nerves, ophthalmic artery and vein, adipose tissue of the orbit, inferior oblique muscle, and eyeball. By its *external surface* with the periosteum of the orbit and lachrymal gland; by the *upper border* with the lachrymal vessels and nerve.

Nerve Supply.—The sixth nerve.

The recti muscles present several characters in common; thus, they are thin, have each the form of an isosceles triangle, bear the same relation to the globe of the eye, and are inserted in a similar manner into the sclerotic, at about two lines from the circumference of the cornea. The points of difference relate to thickness and length; the internal rectus is the thickest and shortest, the external the longest, and the superior the most thin. The insertion of the four recti into the globe of the eye forms a tendinous expansion, which is continued as far as the margin of the cornea, and is termed *tunica albuginea.*

The **OBLIQUUS SUPERIOR** (trochlearis) is a fusiform muscle *arising* from the margin of the optic foramen, and from the fibrous sheath of the optic nerve; it passes forward to the pulley at the internal angular process of the frontal bone; its tendon is then reflected outwards beneath the superior rectus to the outer part of the globe of the eye, where it is *inserted* into the sclerotic coat, at about midway between the margin of the cornea and the optic nerve. The *trochlea* or *pulley* of the superior oblique muscle is a fibro-cartilaginous ring attached to the depression beneath the internal angular process of the frontal bone. The ring is flat, about a line in width, and provided with a synovial membrane, which is continued, together with a fibrous sheath, for a short distance, upon the tendon. Sometimes the ring is supported, or in part formed, by a process of bone.

Relations.—By its *superior surface* with the fourth nerve, supratrochlear nerve, superior rectus, and periosteum of the orbit. By the *inferior surface* with the adipose tissue of the orbit, globe of the eye, upper border of the internal rectus, and the vessels and nerves crossing that border.

Nerve Supply.—The fourth nerve.

The **OBLIQUUS INFERIOR**, a thin and narrow muscle, *arises* from the inner margin of the superior maxillary bone, immediately external to the lachrymal groove, and passes beneath the inferior rectus, to be *inserted* into the outer and posterior part of the eyeball, at about two lines from the entrance of the optic nerve.

Relations.—By its *superior surface* with the inferior rectus muscle and eyeball; by the *inferior surface* with the periosteum of the floor of the orbit, and external rectus.

Nerve Supply.—Inferior division of the third nerve.

FASCIÆ OF THE ORBIT.—The muscles of the orbit are separated from the globe of the eyeball and structures immediately surrounding the optic nerve, by a fascia, which is continuous with the broad tarsal ligament and tarsal cartilages. This fascia is termed *tunica vaginalis oculi*, or *capsule of Tenon*. It surrounds the eyeball except at the anterior part where it is reflected on the inside of the conjunctiva and eyelids, and is pierced anteriorly, for the passage of the six orbital muscles, by six openings, through which the tendons of the muscles play as through pulleys. From this fascia processes pass off into the fat of the orbit, and form delicate sheaths for the muscles; they also divide the cavity of the orbit into a number of loculi filled with fat. These septa of fascia are thickest at the inside near the lachrymal sac, and at the outer side near the margin of the orbit, blending in the latter situation with the external palpebral ligament and periosteum. In several places they contain unstriped muscular tissue as well as elastic tissue, and it is believed that they thus become effective in restoring the eyeball to its position of rest after the muscles have ceased to act.

Actions.—The levator palpebræ raises the upper eyelid. The four recti, acting singly, pull the eyeball in the four directions—upwards, downwards, inwards, and outwards. Acting by pairs, they carry the eyeball in the diagonal of these directions, viz., upwards and inwards, upwards and outwards, downwards and inwards, downwards and outwards. Acting all together, they directly retract the globe within the orbit. The superior oblique muscle, acting alone, rolls the globe inwards and forwards, and carries the pupil outwards and downwards to the lower and outer angle of the orbit. The inferior oblique, acting alone, rolls the globe outwards and backwards, and carries the pupil outwards and upwards to the upper and outer angle of the eye. The superior rectus when acting alone tends not only to raise the eyeball but also to carry it inwards, and rotate it slightly on its own axis; this tendency to invertion and rotation is corrected by the combination of that muscle with the inferior oblique, the latter tending to direct the pupil outwards and

to rotate the ball in the opposite direction to the rectus. In like manner the inferior rectus and superior oblique are combined in their action, the oblique muscle correcting the tendency of the rectus to carry the eyeball inwards, and to rotate the ball on its own axis. In all oblique movements of direction there is a combination of two recti with one oblique muscle; the actions performed by the several muscles, and the way in which they are associated, are well shown in the subjoined table taken from Beaunis' work :—

Number of Muscles in Activity.	Direction of Line of Regard.	Muscles Acting.
One	Inwards	Internal rectus.
	Outwards	External rectus.
Two	Upwards	Superior rectus. Inferior oblique.
	Downwards	Inferior rectus. Superior oblique.
Three	Inwards and Upwards	Internal rectus. Superior rectus. Inferior oblique.
	Inwards and Downwards	Internal rectus. Inferior rectus. Superior oblique.
	Outwards and Upwards	External rectus. Superior rectus. Inferior oblique.
	Outwards and Downwards	External rectus. Inferior rectus. Superior oblique.

5. **Nasal Group.**—

Pyramidalis nasi, Compressor nasi, Dilatator naris, Depressor alæ nasi.

Dissection.—The incision already made down the centre of the nose is to be continued round the margin of the ala to the lower edge of the septum, from thence down the middle of the upper lip to its free margin; from this point it should be carried round the mouth to the middle of the lower lip, and from thence vertically downwards to the chin. The whole of the flap must now be carefully dissected back, care being taken to keep the knife very close to the inner surface of the skin.

The **PYRAMIDALIS NASI** is a small pyramidal slip of muscular fibres sent downwards on the bridge of the nose by the occipito-frontalis. It becomes tendinous and is *inserted* into the tendinous expansion of the compressor nasi.

Relations. — By its *upper surface* with the integument; by its *under surface* with the periosteum of the frontal and nasal bone. Its *outer border* corresponds with the edge of the orbicularis palpebrarum;

its *inner border* with its fellow, from which it is separated by a narrow cellular space.

Nerve Supply.—Infraorbital branch of facial.

The **COMPRESSOR NASI** is a thin and triangular muscle; it *arises* by its apex from the canine ridge of the superior maxillary bone, and spreads out upon the side of the nose into a thin tendinous expansion, which is continuous across the ridge with the muscle of the opposite side and above with the tendon of the pyramidalis nasi. It is connected at its origin with a muscular fasciculus which is attached to the nasal process of the superior maxillary bone immediately below the origin of the levator labii superioris alæque nasi. This muscular slip was termed by Albinus, *musculus anomalus*, from its attachment to bone by both ends; and by Santorinus, *musculus rhomboideus*.

Relations.—By its *superficial surface* with the levator labii superioris proprius, levator labii superioris alæque nasi, and integument; by its *deep surface* with the superior maxillary and nasal bone, and with the alar and lateral cartilage of the nose.

Nerve Supply.—Infraorbital branch of facial.

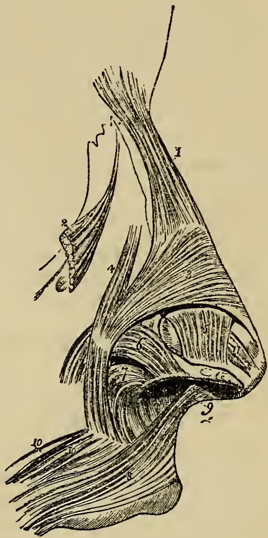


FIG. 180.—Muscles of the nose. 1. Pyramidalis nasi. 2. Upper part of the levator labii superioris alæque nasi turned aside. 3. Compressor nasi. 4. Musculus anomalus. 5. Levator proprius alæ nasi anterior. 6. Levator proprius alæ nasi posterior. 7. Part of the depressor alæ nasi. 8. Upper segment of the orbicularis oris. 9. Naso-labialis. 10. Accessory slips of the orbicularis.

The **DILATATOR NARIS** is a thin and indistinct muscular apparatus expanded on the ala of the nostril, and consisting of an anterior and posterior slip. The anterior slip (**levator proprius alæ nasi anterior**) *arises* from the upper border and surface of the alar cartilage, and is *inserted* into the integument of the border of the nostril. The posterior slip (**levator proprius alæ nasi posterior**) *arises* from the nasal process of the superior maxillary bone and sesamoid cartilages, and is *inserted* into the posterior half of the integument of the border of the nostril. These muscles are difficult of dissection, from the close adhesion of the integument to the nasal cartilages.

Nerve Supply.—Infraorbital branch of facial.

The **DEPRESSOR ALÆ NASI** (depressor labii superioris alæque nasi) is brought into view by drawing upwards the upper lip and raising the mucous membrane. It *arises* from the superior

maxillary bone in front of the roots of the second incisor and canine tooth (myrtiform fossa), and passes upwards and inwards to be *inserted* into the posterior part of the columna and ala nasi. It is closely connected with the deep surface of the orbicularis.

Relations.—By its *superficial surface* with the mucous membrane of the mouth, orbicularis oris, and levator labii superioris alæque nasi; by its *deep surface* with the superior maxillary bone.

Nerve Supply.—Infraorbital branch of facial.

Actions.—The pyramidalis nasi, as a point of attachment of the occipito-frontalis, assists that muscle in its action: it also draws down the inner angle of the eyebrow and produces short horizontal wrinkles across the root of the nose. By its insertion it fixes the aponeurosis of the compressores nasi, and tends to elevate the nose. The compressores nasi appear to act in expanding rather than compressing the nares; hence probably the collapsed state of the nares from paralysis of these muscles in the last moments of life, or in compression of the brain. The dilatator naris is a dilator of the nostril, and the depressor alæ nasi draws downwards both the ala and columna of the nose, the depression of the latter being assisted by the naso-labialis.

6. **Superior Labial Group.**—

Orbicularis oris,	Levator anguli oris,
Levator labii superioris alæque nasi,	Zygomaticus major,
Levator labii superioris proprius,	Zygomaticus minor.

Dissection.—The skin has been already removed in order to display the preceding group, but it is necessary now to put a hook in the angle of the mouth and carry it downwards, so as to keep the muscles of the upper lip on the stretch during the removal of the muscular fascia.

The **ORBICULARIS ORIS** is a sphincter muscle, completely surrounding the mouth, and possessing consequently neither origin nor insertion. It is composed of two thick semicircular planes of fibres, which embrace the rima of the mouth, and interlace at their extremities, where they are continuous with the fibres of the buccinator and the other muscles connected with the angle of the mouth. The upper segment is attached by means of a small muscular fasciculus (naso-labialis) to the columna of the nose: and other fasciculi connected with both segments, and attached to the maxillary bones, are termed "accessorii." Several anatomists consider the orbicularis as composed of two portions, *internal* or *marginal*, in immediate contact with the lips, and thick; and *external*, broad and thin; the separation between the two being indicated by the coronary arteries. The internal fibres are continued uninterruptedly from one lip to the other round the angle of the mouth, the external fibres decussate with those of the buccinator, the upper fibres of the orbicularis being continued into the lower ones of the latter muscle, and *vice versâ*.

Relations.—By its *superficial surface* with the integument of the

lips, with which it is closely connected. By its *deep surface* with the mucous membrane of the mouth, the labial glands and coronary arteries being interposed. By its *circumference* with the numerous muscles which move the lips, and by the *inner border* with the mucous membrane of the margin of the mouth.

Nerve Supply.—Infraorbital and buccal branches of the facial.

The **LEVATOR LABII SUPERIORIS ALÆQUE NASI** is a thin triangular muscle; it *arises* from the upper part of the nasal process of the superior maxillary bone; and, becoming broader as it descends, is *inserted* by two portions, one into the ala of the nose, the other into the orbicularis oris and upper lip.

Relations.—By its *superficial surface* with the orbicularis palpebrarum, facial artery, and integument. By its *deep surface* with the superior maxillary bone, musculus anomalus, compressor nasi, dilatator naris, and alar cartilage.

Nerve Supply.—Infraorbital branch of facial.

The **LEVATOR LABII SUPERIORIS PROPRIUS** is a thin quadrilateral muscle; it *arises* from the lower border of the orbit, immediately above the infraorbital foramen, and passing obliquely downwards and inwards, is *inserted* into the integument of the upper lip, its deep fibres being blended with those of the orbicularis.

Relations.—By its *superficial surface* with the lower segment of the orbicularis palpebrarum, facial artery, and integument. By its *deep surface* with the compressor nasi, levator anguli oris, orbicularis oris, and infraorbital artery and nerve.

Nerve Supply.—Infraorbital branch of facial.

The **LEVATOR ANGULI ORIS** (caninus) *arises* from the canine fossa of the superior maxillary bone, and passes obliquely downwards and outwards to be *inserted* into the angle of the mouth; its fibres being continued into the inferior segment of the orbicularis and depressor anguli oris.

Relations. — By its *superficial surface* with the levator labii superioris proprius, branches of the infraorbital artery and nerve, and inferiorly with the integument. By its *deep surface* with the superior maxillary bone and buccinator muscle.

Nerve Supply.—Infraorbital branch of facial.

The **ZYGOMATIC** muscles are two slender fasciculi of fibres which *arise* from the malar bone, and are *inserted* into the upper lip. The zygomaticus major descends to the angle of the mouth, and is continuous with the inferior segment of the orbicularis, depressor anguli oris, and risorius Santorini. The zygomaticus minor, lying in front of the major, becomes connected with the outer border of the levator labii superioris proprius, and is attached to the integument of the upper lip. This muscle is often wanting.

Relations.—The *zygomaticus major* is in relation by its *superficial surface* with the lower segment of the orbicularis palpebrarum above, and with the fat of the cheek and integument for the rest of its extent. By its *deep surface* with the malar bone, masseter, buccinator, and facial vessels. The *zygomaticus minor* being in front

of the major, has no relation with the masseter; inferiorly it rests on the levator anguli oris.

Nerve Supply.—Infraorbital branch of facial.

Actions.—The orbicularis oris produces the direct closure of the lips by means of its continuity, at the angles of the mouth, with the fibres of the buccinator. When acting singly in the forcible closure of the mouth, the integument is thrown into wrinkles, in consequence of its firm connection with the surface of the muscle; its naso-labial fasciculus draws downwards the columna nasi. The levator labii superioris alæque nasi lifts the upper lip with the ala of the nose, and expands the opening of the nares. The levator labii superioris proprius is the proper elevator of the upper lip: acting singly, it draws the lip a little to one side. The levator proprius, and still more the levator alæ nasi, is brought into play in the expression of contempt or derision. The levator anguli oris lifts the angle of the mouth and draws it inwards, while the zygomatici pull it upwards and outwards, as in laughing, and produce the dimple in the cheek. In the movement of laughter the zygomatici are assisted by the risorius Santorini.

7. Inferior Labial Group.—

Depressor labii inferioris,	Risorius Santorini,
Depressor anguli oris,	Levator labii inferioris.

Dissection.—To dissect the inferior labial region, continue the incision already made along the margin of the lower jaw to its angle. Dissect off the integument and superficial fascia from this surface, and the muscles of the inferior labial region will be exposed.

The **DEPRESSOR LABII INFERIORIS** (quadratus menti) *arises* from the oblique line by the side of the symphysis of the lower jaw, and passing upwards and inwards, is *inserted* into the orbicularis muscle and integument of the lower lip. Its inner fibres interlace with those of the opposite muscle, the outer fibres reach nearly to the angle of the mouth. This muscle is very thin, and pale in colour, and its fibres are mixed with a considerable quantity of fat, so that it is very difficult to make a good dissection of it.

Relations.—By its *superficial surface* with the platysma myoides, part of the depressor anguli oris, and the integument of the chin with which it is closely connected. By the *deep surface* with the levator labii inferioris, labial glands, mucous membrane of the lower lip, and mental nerve and artery.

Nerve Supply.—Supra-maxillary of facial.

The **DEPRESSOR ANGULI ORIS** (triangularis) is a triangular plane of muscle *arising* by a broad base from the external oblique ridge of the lower jaw just below the mental foramen, and *inserted* by its apex into the angle of the mouth, where it is continuous with the levator anguli oris, zygomaticus major, and upper segment of the orbicularis. Near its insertion it is joined by the following muscle:—

Relations.—By its *superficial surface* with the integument; by

its *deep surface* with the depressor labii inferioris, buccinator, and branches of the mental nerve and artery.

Nerve Supply.—Supra-maxillary of facial.

The **RISORIUS SANTORINI** is a thin and triangular muscle, consisting of a few scattered fasciculi of fibres which *arise* from the fascia covering the masseter muscle, and converge to the angle of the mouth, where they become connected with the outer border of the depressor anguli oris, and continuous with the zygomaticus major. This muscle is generally regarded as a part of the platysma myoides.

Nerve Supply.—Supra-maxillary of facial.

The **LEVATOR LABII INFERIORIS** (levator menti) is to be dissected by everting the lower lip, and raising the mucous membrane. It is a short but strong muscle *arising* from the incisive fossa of the lower jaw, and *inserted* into the integument of the chin. It is in relation with the mucous membrane of the mouth, with its fellow, and with the depressor labii inferioris.

Nerve Supply.—Supra-maxillary of facial.

The whole of the muscles of the face have attachments to the integuments, as well as to each other and to the bones, and it is chiefly in consequence of the integumentary attachments that they act as muscles of expression, for it is by this means that the ridges and furrows which give such characteristic expressions to the face are produced.

Actions.—The depressor labii inferioris draws the lower lip downwards, and a little outwards. The depressor anguli oris, from the radiated direction of its fibres, will pull the angle of the mouth either downwards and forwards, or downwards and backwards, and be expressive of grief; or acting with the levator anguli oris, zygomaticus major, and risorius Santorini, will draw the angle of the mouth upwards and backwards, or directly backwards. The levator labii inferioris raises and protrudes the integument of the chin.

8. **Maxillary Group.**—

Masseter,	Buccinator,
Temporal,	Pterygoideus externus,
	Pterygoideus internus.

Dissection.—The flap already obtained must be carried as far back as the posterior margin of the ramus of the jaw, and the structures which cover the masseter must be cut away.

Fascia.—The masseter muscle is covered by a strong layer of fascia continued on to it from the surface of the parotid gland (*parotideo-masseteric fascia*); below, it may be traced into the neck, where it is found to be continuous with the anterior layer of the deep cervical fascia. It is intimately connected with the tendinous fibres of the muscle, and is attached above to the lower border of the zygomatic arch.

The **MASSETER** (*μασσάομαι*, to chew) is a short, thick, and somewhat quadrilateral muscle, composed of two planes of fibres, super-

ficial and deep. The *superficial* layer *arises* by a strong aponeurosis from the malar process of the superior maxillary bone and lower border of the malar bone, and passes downwards and backwards to be *inserted* into the ramus and angle of the inferior maxilla. The *deep* layer arises from the lower border of the malar bone and zygomatic process of the temporal, and passes downwards and forwards, to be *inserted* into the upper half of the ramus.

Relations.—By its *external surface* with the zygomaticus major, risorius Santorini and platysma myoides, parotid gland and Stenson's duct, transverse facial artery, pes anserinus, and integument. By its *internal surface* with the temporal muscle, buccinator, from which it is separated by a mass of fat, and ramus of the lower jaw. By its *posterior border* with the parotid gland; by the *anterior border* with the facial artery and vein.

Nerve Supply.—Masseteric branch of the inferior maxillary of the fifth cerebral nerve.

FASCIA.—The strong aponeurotic layer which covers the temporal muscle is called the **temporal fascia** or **aponeurosis**; it is attached above to the posterior border of the malar bone and the temporal ridge on the frontal, parietal, and temporal bones. Below it separates into two layers, between which there is a small quantity of fat, a small nerve derived from the orbital branch of the superior maxillary nerve, and the orbital branch of the temporal artery. Of these two layers one is attached to the outer, and the other to the inner surface of the zygoma.

Dissection.—Make an incision along the upper border of the zygoma, for the purpose of separating the temporal fascia from its attachment. Then saw through the zygomatic process of the malar bone, and through the root of the zygoma near the meatus auditorius. Draw down the zygoma, and with it the origin of the masseter, and dissect the latter muscle away from the ramus and angle of the inferior maxilla. Now remove the temporal fascia from the rest of its attachment, and the whole of the temporal muscle will be brought into view.

The **TEMPORAL** is a broad and radiating muscle, occupying a considerable extent of the side of the head, and filling the temporal fossa. It *arises* by tendinous fibres from the whole length of the temporal ridge, and by muscular fibres from the temporal fascia and entire surface of the temporal fossa, excepting the anterior or malar wall. Its fibres converge to a strong and narrow tendon, which is *inserted* into the apex, internal surface, and anterior border of the coronoid process of the lower jaw, as far down as the junction of the body and ramus.

Relations.—By its *external surface* with the temporal fascia (which separates it from the attollens and attrahens auriculam muscles, and temporal vessels and nerves) and with the zygoma and masseter. By its *internal surface* with the bones forming the temporal fossa, the external pterygoid muscle, part of the buccinator, and the internal maxillary artery with its deep temporal branches.

Nerve Supply.—Temporal branches of the inferior maxillary of the fifth cerebral nerve.

Dissection.—By sawing through the coronoid process near its base, and pulling it upwards, together with the temporal muscle, which may be dissected from the fossa, we obtain a view of the entire extent of the buccinator and external pterygoid muscles.

The **BUCCINATOR** (*buccina*, a trumpet), the trumpeter's muscle, *arises* from the alveolar process of the superior maxillary bone, corresponding to the three molar teeth, and the *pterygo-maxillary ligament.* This ligament is the raphé of union between the buccinator and superior constrictor muscles, and is attached by one extremity to the hamular process of the internal pterygoid plate, and by the other to the extremity of the molar ridge of the lower jaw. The fibres of the muscle converge towards the angle of the mouth, where some are continuous with the levator and depressor anguli oris, and the greater number cross each other, the superior being continuous with the inferior segment of the orbicularis oris, the inferior with the superior segment. The fibres along the upper border of the muscle pass directly into the upper fibres of the orbicularis and do not decussate, and those along the lower border in like manner pass directly into the lower fibres of that muscle. The muscle is invested externally by a thin fascia (buccal) which extends backwards to the pharynx.

Relations.—By its *external surface*, posteriorly, with a large and rounded mass of fat, which separates the muscle from the ramus of the lower jaw, temporal, and masseter: *anteriorly* with the risorius Santorini, zygomatici, levator anguli oris, and depressor anguli oris. It is also in relation with a part of Stenson's duct (which pierces it opposite the second molar tooth of the upper jaw), with the transverse facial artery, branches of the facial and buccal nerve, and facial artery and vein. By its *internal surface* with the buccal glands and mucous membrane of the mouth.

Nerve Supply.—Buccal branch of facial, which supplies it on its superficial surface.

The **PTERYGOIDEUS EXTERNUS** is a short and thick muscle, broader at its origin than at its insertion. It *arises* by two heads, *one* from the under surface of the great wing of the sphenoid and pterygoid ridge; the *other* from the outer surface of the external pterygoid plate, tuberosity of the palate bone and tuberosity of the superior maxillary. The fibres pass backwards to be *inserted* into the neck of the lower jaw, and into the interarticular fibro-cartilage. The internal maxillary artery passes between the two heads of this muscle.

Relations.—By its *external surface* with the ramus of the lower jaw, temporal muscle, and internal maxillary artery; by its *internal surface* with the internal pterygoid muscle, internal lateral ligament of the jaw, middle meningeal artery, and inferior maxillary nerve; by its *upper border* with the muscular branches of the inferior maxillary nerve; the internal maxillary artery passes between its two heads, and its lower head is pierced by the buccal nerve.

Nerve Supply.—Buccal branch of inferior maxillary of fifth cerebral nerve.

Dissection.—The condyle of the jaw must now be removed from its socket, and, together with the external pterygoid, be turned over towards the nose, so as to expose the internal pterygoid.

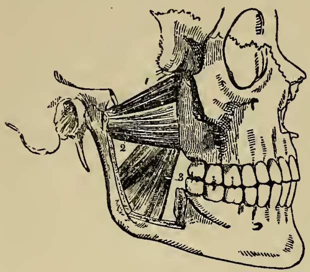


FIG. 181.—The two pterygoid muscles. The zygomatic arch and the greater part of the ramus of the lower jaw have been removed in order to bring these muscles into view. 1. The sphenoid head of the external pterygoid. 2. Its pterygoid head. 3. The internal pterygoid.

The **PTERYGOIDEUS INTERNUS** is a thick quadrangular muscle. It *arises* from the pterygoid fossa, being attached to the inner surface of the external pterygoid plate, and that part of the tuberosity of the palate bone which is interposed between the pterygoid plates; it also occasionally gets an additional origin from the angle between the outer surface of the external pterygoid plate and the tuberosity of the superior maxillary bone. It descends obliquely backwards, to be *inserted* into the ramus and angle of the lower jaw. It resembles the masseter in appearance and direction, and was named by Winslow *internal masseter.*

Relations.—By its *external surface* with the external pterygoid, inferior maxillary nerve and branches, internal maxillary artery and branches, internal lateral ligament, and ramus of the lower jaw. By its *internal surface* with the tensor palati, superior constrictor and fascia of the pharynx; by its posterior border with the parotid gland.

Nerve Supply.—Pterygoid branch of inferior maxillary of fifth cerebral.

Actions.—The maxillary muscles are the active agents in mastication, and form an apparatus admirably fitted for that office. The buccinator circumscribes the cavity of the mouth, and with the aid of the tongue keeps the food under the immediate pressure of the teeth. By means of its connection with the superior constrictor, it shortens the cavity of the pharynx from before backwards, and becomes an auxiliary in deglutition. The temporal, the masseter, and the internal pterygoid are the bruising muscles, drawing the lower jaw against the upper with great force. The two latter, from the obliquity of their direction, assist the external pterygoid in grinding the food, by carrying the lower jaw forward upon the upper; the jaw being brought back again by the deep portion of the masseter and posterior fibres of the temporal. The external pterygoid muscles, when both act together, draw the jaw forwards, but more frequently they act alternately, each drawing the jaw forwards and towards the opposite side, so as to produce by their alternate action the grinding

movements of the molar teeth. The internal pterygoid assists the external muscle of the same side in protracting the jaw, and throwing the teeth towards the opposite side. The whole of these muscles, acting in succession, produce a rotatory movement of the teeth upon each other, which, with the direct action of the lower jaw against the upper, effects the mastication of the food.

MUSCLES AND FASCIÆ OF THE NECK.

The muscles of the neck may be arranged into eight groups, corresponding with the natural divisions of the region; they are :—

1. Superficial group.
2. Depressors of the os hyoides and larynx.
3. Elevators of the os hyoides and larynx.
4. Lingual group.
5. Pharyngeal group.
6. Palatine group.
7. Prævertebral group.
8. Laryngeal group.

The muscles in each group are as follow :—

1. Superficial Group.

Platysma myoides,
Sterno-cleido-mastoid.

2. Depressors of the Os Hyoides and Larynx.

Sterno-hyoid,
Sterno-thyroid,
Thyro-hyoid,
Omo-hyoid.

3. Elevators of the Os Hyoides and Larynx.

Digastricus,
Stylo-hyoid,
Mylo-hyoid,
Genio-hyoid,
Genio-hyo-glossus.

4. Muscles of the Tongue.

Genio-hyo-glossus,
Hyo-glossus,
Lingualis,
Stylo-glossus,
Palato-glossus.

5. Muscles of the Pharynx.

Inferior constrictor,
Middle constrictor.
Superior constrictor.
Stylo-pharyngeus.
Palato-pharyngeus.

6. Muscles of the Soft Palate.

Levator palati,
Tensor palati,
Azygos uvulæ,
Palato-glossus,
Palato pharyngeus.

7. Prævertebral Group.

Rectus anticus major,
Rectus anticus minor,
Scalenus anticus,
Scalenus medius,
Scalenus posticus,
Longus colli.

8. Muscles of the Larynx.

Crico-thyroid,
Crico-arytænoideus posticus,
Crico-arytænoideus lateralis,
Thyro-arytænoideus,
Arytænoideus.

Dissection.—The dissection of the neck should be commenced by making an incision along the middle line of its forepart from the chin to the sternum, and bounding it superiorly and inferiorly by two transverse incisions; the superior being carried along the margin of the lower jaw, and across the mastoid process to the tubercle on the occipital bone, the inferior along the clavicle to the acromion process. The square flap of integument thus included should be turned back from the entire side of the neck, which brings into view the superficial fascia, and on the removal of a thin layer of this the platysma myoides will be exposed.

The **superficial cervical fascia** is a part of the common superficial fascia of the entire body, and is only interesting from containing between its layers the platysma myoides muscle.

The **PLATYSMA MYOIDES** (πλατὺς μῦς εἶδος, broad muscle-like lamella) is a thin plane of muscular fibres, situated beneath the integument on the side of the neck. It *arises* from the fascia over the pectoralis major and deltoid muscle, and from the clavicle and acromion; it passes obliquely upwards and inwards to be *inserted* into the side of the chin, oblique line of the lower jaw, angle of the mouth, and integument of the face. The anterior fibres mingle beneath the chin with those of the muscle of the opposite side; the next interlace with the depressor anguli oris and depressor labii inferioris; the posterior fibres are disposed in a transverse direction across the lower part of the face, arising from the fascia over the parotid gland and masseter muscle, and inserted into the angle of the mouth, where they form part of the risorius Santorini muscle. The entire muscle is analogous to the cutaneous muscle of brutes, the panniculus carnosus.

Relations.—By its *external surface* with the integument, with which it is closely adherent below, but loosely above. By its *internal surface*, below the clavicle, with the pectoralis major and deltoid; in the neck with the trapezius, sterno-mastoid, external jugular vein and deep cervical fascia; on the face, with the parotid gland, masseter, facial artery and vein, buccinator, depressor anguli oris, and depressor labii inferioris.

Nerve Supply.—Its upper part by the facial, its lower by the superficial, cervical.

Dissection.—The platysma is now to be removed, commencing in front and turning it backwards towards the spine; great care must be taken not to cut the branches of the superficial cervical plexus, or the external jugular vein which lies beneath it. The deep cervical fascia will now be exposed, and must be carefully studied.

The **deep cervical fascia** is a strong areolo-fibrous membrane, which invests the muscles of the neck, and retains and supports the vessels and nerves. It commences posteriorly at the ligamentum nuchæ, and passes forwards at each side beneath the trapezius muscle to the posterior border of the sterno-mastoid; here it divides into two layers, which embrace that muscle and unite upon its anterior border to be prolonged onwards to the middle line of the

neck, where it is continuous with the fascia of the opposite side. Besides constituting a sheath for the sterno-mastoid, it also forms sheaths for the other muscles of the neck over which it passes. If the superficial layer (anterior layer) of the sheath of the sterno-mastoid be traced upwards, it will be found to pass over the parotid gland and masseter muscle (fascia parotideo-masseterica), to be inserted into the zygomatic arch; traced downwards, it will be seen to pass to the front of the clavicle, to which it becomes attached. If the deep layer (posterior layer) of the sheath be examined superiorly, it will be found attached to the styloid process, from which it is reflected to the angle of the lower jaw, forming the *stylo-maxillary ligament;* followed downwards, a process of it will be found connected with the tendon of the omo-hyoid muscle, binding it down to the clavicle, while still lower it becomes continuous with the costo-coracoid membrane. It is pierced in the posterior triangle of the neck by the external jugular vein. In the middle line the deep cervical fascia is thin above where it becomes attached to the

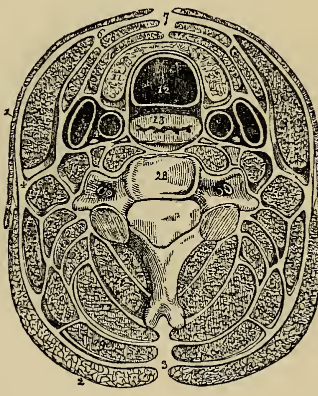


FIG. 182.—Transverse section of the neck, showing the deep cervical fascia and its prolongations forming sheaths for the muscles. 1. Platysma myoides. 2. Trapezius. 3. Ligamentum nuchæ. 4. The point at which the fascia divides to form the sheath for the sterno-mastoid (5). 6. The point of reunion of the two layers. 7. The point of union of the fascia of opposite sides of the neck. 8. Sterno-hyoid. 9. Omo-hyoid. 10. Sterno-thyroid. 11. Lateral lobe of the thyroid gland. 12. Trachea. 13. Œsophagus. 14. Carotid sheath. 15. Longus colli. The nerve in front of the sheath of this muscle is the sympathetic. 16. Rectus anticus major. 17. Scalenus anticus. 18. Scalenus medius. 19. Splenius capitis. 20. Splenius colli. 21. Levator anguli scapulæ. 22. Complexus. 23. Trachelo-mastoid. 24. Transversalis cervicis. 25. Cervicalis ascendens. 26. Semi-spinalis colli. 27. Multifidus spinæ. 28. Cervical vertebra.

hyoid bone, but as it descends it becomes thicker and splits into two layers, a superficial and a deep, between which there is a little fat and areolar tissue, as well as a lymphatic gland. The superficial of these layers is attached to the anterior edge of the sterno-mastoid, and below to the sternum and inter-clavicular ligament; the deep layer is intimately connected with the sterno-hyoid and sterno-thyroid, ensheathing them, and becoming attached to the posterior surface of the sternum. Still deeper in the anterior triangle, a thin sheet of fascia passes behind the depressor muscles of the hyoid to invest the thyroid body, and being continued on to the trachea may be traced to the fibrous layer of the pericardium, with which it blends.

The deep cervical fascia also forms a sheath for the common carotid artery, internal jugular vein, and pneumogastric nerve, a fibrous septum intervening between the artery and vein. That portion of the fascia which covers the muscles lying on the front of the vertebral column, and intervenes between them and the pharynx and œsophagus, is called the *pre-vertebral fascia.*

Dissection.—Remove the deep cervical fascia and expose the sterno-mastoid muscle.

The **STERNO-CLEIDO MASTOID** is the large oblique muscle of the neck, and is situated between two layers of the deep cervical fascia. It *arises*, as implied by its name, from the sternum and clavicle (*κλειδίον*), and passes obliquely upwards and backwards, to be *inserted* into the mastoid process of the temporal, and superior curved line of the occipital bone. The sternal portion arises by a rounded tendon, increases in breadth as it ascends, and spreads out to a considerable extent at its insertion. The clavicular portion is

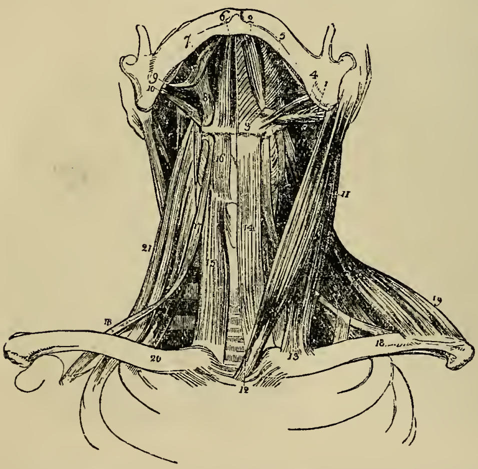


FIG. 183.—Muscles of the anterior aspect of the neck; on the right side of the figure the superficial muscles are seen, on the left the deep. 1. Posterior belly of digastricus. 2. Its anterior belly. Aponeurotic pulley, through which its tendon is seen passing, attached to the body of the os hyoides. 3. 4. Stylo-hyoid muscle, transfixed by the posterior belly of the digastricus. 5. Mylo-hyoid. 6. Genio-hyoid. 7. The tongue. 8. Hyo-glossus. 9. Stylo-glossus. 10. Stylo-pharyngeus. 11. Sterno-mastoid. 12. Its sternal origin. 13. Its clavicular origin. 14. Sterno-hyoid. 15. Sterno-thyroid of the right side. 16. Thyro-hyoid. 17. Hyoid portion of the omo-hyoid. 18, 18. Its scapular portion; on the left side, the tendon of the muscle is seen to be bound down by a portion of the deep cervical fascia. 19. Clavicular portion of the trapezius. 20. Scalenus anticus, of the right side. 21. Scalenus posticus; the scalenus medius is seen between the two.

broad and fleshy, separate from the sternal portion below, but blended with the posterior surface of the latter as it ascends.

The two portions of this muscle are sometimes described as separate muscles under the names of *sterno-mastoid* and *cleido-mastoid*, these being again occasionally subdivided, the first into *sterno-mastoid* and *sterno-occipital*, and the second into *cleido-mastoid* and *cleido-occipital.* The cleido-mastoid is the most deeply seated slip of the muscle, and

has a separate attachment to the mastoid process; it is generally perforated by the spinal accessory nerve.

Relations.—By its *superficial surface* with the integument, platysma myoides, external jugular vein, superficial branches of the cervical plexus of nerves, and anterior layer of the deep cervical fascia. By its *deep surface* with the deep layer of the cervical fascia, sterno-clavicular articulation, sterno-hyoid, sterno-thyroid, omohyoid, scaleni, levator anguli scapulæ, splenii, and posterior belly of the digastricus muscle; phrenic nerve, transversalis colli and suprascapular artery; deep lymphatic glands, sheath of the common carotid and internal jugular vein, descendens noni nerve, external carotid artery with its posterior branches, and commencement of the internal carotid artery; cervical plexus of nerves, pneumogastric, spinal accessory, hypoglossal, sympathetic, and facial nerve, and parotid gland. It is pierced on this aspect by the spinal accessory nerve.

Nerve Supply.—Spinal accessory nerve.

Actions.—The platysma produces a muscular traction on the integument of the neck, which prevents it from falling so flaccid in old persons as it would if the extension of the skin were the mere result of elasticity. It draws also on the angle of the mouth, and is one of the depressors of the lower jaw. It assists in the expression of the emotion of fright or extreme fear. The sterno-mastoid muscles (nutatores capitis) are the great anterior muscles of connection between the thorax and the head. Both muscles acting together bow the head directly forwards. The clavicular portions, acting more forcibly than the sternal, give stability and steadiness to the head in supporting weights. Either muscle acting singly would draw the head towards the shoulder of the same side, and carry the face towards the opposite side.

Regional Anatomy of the Neck.

The region of the neck is divided into two great triangles by the sterno-mastoid muscle. The **posterior triangle** is bounded by the posterior border of the muscle, by the clavicle, and by the anterior edge of the trapezius. The **anterior triangle** is bounded by the anterior border of the sterno-mastoid, by the lower border of the inferior maxilla, and a line drawn from the angle of this bone to the mastoid process, and by the mesial line.

The posterior triangle is subdivided into two by the scapular belly of the omo-hyoid muscle. The **posterior superior triangle** (occipital triangle) is bounded by the posterior border of the sterno-mastoid, the anterior edge of the trapezius, and the posterior belly of the omo-hyoid. Its floor is formed from above downwards by the splenius capitis, levator anguli scapulæ, scalenus posticus, scalenus medius, and upper digitation of the serratus magnus muscles. It contains the superficial descending branches of the cervical plexus, the spinal accessory nerve, the transversalis colli artery and vein, the superficialis colli artery, and the cervical lymphatics and glands.

The **posterior inferior** or **subclavian triangle** is bounded by the clavicle, the posterior belly of the omo-hyoid, and the posterior border of the sterno-mastoid. A **deeper subclavian** space is bounded by the two former sides, and the third is the outer edge of the scalenus anticus. This triangle contains the third part of the subclavian artery, above and behind which are the trunks of the brachial plexus ; below, and in front of it, almost overlapped by the clavicle, the subclavian vein, in close proximity to which behind the clavicle is the transversalis humeri artery, both of which vessels, although not strictly *in* the triangle, are apt to invade it as soon as the fascia is divided in the operation for ligature of the subclavian. The external jugular vein terminates in the subclavian vein about the middle of this space ; near its termination it receives the transversalis colli and suprascapular veins.

The **anterior triangle** has been divided into three. The inferior carotid, the superior carotid, and the submaxillary. The **inferior carotid triangle** is bounded by the mesial line, the anterior border of the sterno-mastoid, and the anterior belly of the omo-hoid.

The **superior carotid triangle** (the place of selection for ligature of the carotid artery) is bounded by the anterior border of the sterno-mastoid, the anterior belly of the omo-hyoid, and the posterior belly of the digastricus.

The **submaxillary triangle** is bounded above by the lower border of the body of the lower jaw, the parotid gland and mastoid process, below by the posterior belly of the digastricus and the stylo-hyoid, in front by the mesial line. Its floor is formed by the anterior belly of the digastricus, the mylo-hyoid and hyo-glossus muscles. The space contains the submaxillary gland, facial artery and vein, submental artery, mylo-hyoid artery and nerve, external carotid artery, part of the parotid gland, internal carotid artery, commencement of external and anterior jugular veins, pneumogastric and glosso-pharyngeal nerves, and submaxillary lymphatic vessels and glands.

Second Group.—Depressors of the Os Hyoides and Larynx.

Sterno-hyoid,	Thyro-hyoid,
Sterno-thyroid,	Omo-hyoid.

Dissection.—These muscles are brought into view by removing the deep fascia from off the front of the neck between the two sterno-mastoid muscles. The omo-hyoid to be seen in its whole extent requires that the sterno-mastoid muscle be divided from its origin and turned aside.

The **STERNO-HYOID** is a narrow ribbon-like muscle, *arising* from the posterior surface of the first bone of the sternum and from the posterior sterno-clavicular ligament (sometimes from the inner extremity of the clavicle, and sometimes from the cartilage of the first rib). It is *inserted* into the lower border of the hyoid bone.

The sterno-hyoid muscles are separated by a considerable interval at the root of the neck, approach each other as they ascend, and are again separated on the thyroid cartilage; they are frequently traversed below by a tendinous intersection.

Relations.—By its *superficial surface* with the sternum, sternal end of clavicle, deep cervical fascia, platysma myoides and sterno-mastoid muscle; by its *deep surface* with the sterno-thyroid, crico-thyroid, and thyro-hyoid muscles, superior thyroid artery, thyroid gland, crico-thyroid and thyro-hyoid membranes.

Nerve Supply.—Descendens noni, a branch of the hypoglossal.

The **STERNO-THYROID**, broader than the preceding, beneath which it lies, *arises* from the posterior surface of the upper bone of the sternum, and from the cartilage of the first rib; it is *inserted* into the oblique line on the great ala of the thyroid cartilage. The inner borders lie in contact along the middle line, and the muscles are marked by a tendinous intersection at their lower part. Some of the fibres of this muscle are continued directly into the thyro-hyoid without intervening attachment; others are continuous with the inferior constrictor.

Relations.—By its *external surface* with the sterno-hyoid, omo-hyoid, and sterno-mastoid muscle; by its *internal surface*, with the trachea, inferior-thyroid veins, thyroid gland, lower part of the larynx, sheath of the common carotid artery, and internal jugular vein, subclavian vein, vena innominata, and on the right side, arteria innominata. The middle thyroid vein lies along its inner border.

Nerve Supply.—Descendens noni.

The **THYRO-HYOID** is the continuation upwards of the sterno-thyroid muscle. It *arises* from the oblique line on the thyroid cartilage, and is *inserted* into the lower border of the body, and great cornu of the os hyoides for one-half its length.

Relations.—By its *external surface* with the sterno-hyoid and omo-hyoid muscle; by its *internal surface* with the great ala of the thyroid cartilage, thyro-hyoid membrane, and superior laryngeal artery and nerve.

Nerve Supply.—A special branch of the hypoglossal.

The **OMO-HYOID** (*ὦμος*, shoulder) is a double-bellied muscle passing obliquely across the neck from the scapula to the os hyoides; it forms an obtuse angle behind the sterno-mastoid, and is retained in that position by a process of the deep cervical fascia which forms a sheath for its tendon and holds it in connection with the sternum and first rib. It *arises* from the upper border of the scapula and transverse ligament of the suprascapular notch, and is *inserted* into the hyoid bone at the junction of the body and great cornu.

Relations.—By its *superficial surface* with the trapezius, sub-clavius, clavicle, deep cervical fascia, platysma myoides, sterno-mastoid, and integument. By its *deep surface* with the brachial plexus, scaleni muscles, phrenic nerve, sheath of the common carotid artery and jugular vein, descendens noni nerve, sterno-

thyroid and thyro-hyoid muscle, and the sterno-hyoid at its insertion.

Nerve Supply.—Descendens noni.

Actions.—The four muscles of this group are depressors of the hyoid bone and larynx. The three former drawing these parts downwards in the middle line, and the two omo-hyoid muscles regulating their traction to the one or other side of the neck, according to the position of the head. The omo-hyoid muscles, by means of their connection with their cervical fascia, are rendered tensors of that portion of the deep fascia which covers the lower part of the neck, between the two sterno-mastoid muscles. The thyro-hyoid muscles, by approximating the hyoid bone to the thyroid cartilage, relax the hyo-epiglottic ligament, and permit the epiglottis to fall down over the aperture of the larynx during deglutition (G. Buchanan).

Third Group.—Elevators of the Os Hyoides.

Digastricus,	Genio-hyoid,
Stylo-hyoid,	Genio-hyo-glossus.
Mylo-hyoid,	

Dissection.—These are best dissected by placing a high block beneath the neck, and throwing the head backwards. The integument has been already dissected away, and the removal of some cellular tissue and fat brings them clearly into view.

The **DIGASTRICUS** (δὶς, twice; γαστὴρ, belly; biventer) is a small muscle situated immediately beneath the side of the body of the lower jaw; fleshy at each extremity, and tendinous in the middle. It *arises* from the digastric fossa and anterior border of the mastoid process of the temporal bone; pierces by its posterior belly the stylo-hyoid muscle, and is *inserted* into a depression on the inner side of the lower jaw, close to the symphysis. The middle tendon is held in connection with the body of the os hyoides by an aponeurotic loop, through which it plays as through a pulley; the loop being lubricated by a synovial membrane. A thin layer of aponeurosis is given off from the tendon of the digastricus at each side, which is connected with the body of the os hyoides, and forms a strong plane of fascia between the anterior portions of the two muscles. This fascia, the *supra-hyoidean*, is continuous with the deep cervical fascia.

Relations.—By its *superficial surface* with the platysma myoides, sterno-mastoid, trachelo-mastoid, anterior fasciculus of the stylo-hyoid muscle, parotid gland, and submaxillary gland. By its *deep surface* with the styloid muscles, hyo-glossus, mylo-hyoid, external carotid artery, lingual and facial artery, internal carotid artery, jugular vein, and hypoglossal nerve.

Nerve Supply.—The anterior belly of the digastric muscle is supplied by the mylo-hyoid nerve, a branch of the inferior maxillary; the posterior belly by a branch of the facial.

The **STYLO-HYOID** is a small and slender muscle situated in immediate relation with the posterior belly of the digastricus, by which it is pierced. It *arises* from the middle of the styloid process, its outer side, and is *inserted* in the body of the os hyoides near the middle line.

Relations.—By its *superficial surface* with the posterior belly of the digastricus, parotid gland and submaxillary gland ; its deep relations are similar to those of the posterior belly of the digastricus.

Nerve Supply.—A branch of the facial.

Dissection.—The digastricus and stylo-hyoid must be removed from their connection with the lower jaw and os hyoides, and turned aside in order to see the next muscle.

The **MYLO-HYOID** (μύλη, mola, *i.e.*, attached to the molar ridge of the lower jaw) is a broad and triangular plane of muscular fibres, forming, with its fellow of the opposite side, the inferior wall or floor of the mouth. It *arises* fleshy from the whole length of the molar ridge of the lower jaw, from the symphysis to the last molar tooth, and proceeds inwards and backwards to the middle line, where its fibres are continuous with those of the opposite side, the posterior fibres being *inserted* into the lower border of the body of the os hyoides. At the middle line the union is tendinous on the upper surface in front, on the lower behind, the rest being fleshy.

Relations.—By its *superficial* or inferior *surface*, with the platysma myoides, digastricus, supra-hyoidean fascia, submaxillary gland, submental artery and mylo-hyoidean nerve and artery. By its *deep* or superior *surface* with the genio-hyoid, genio-hyo-glossus, hyo-glossus, stylo-glossus, gustatory nerve, hypoglossal nerve, Wharton's duct, sublingual gland, and mucous membrane of the floor of the mouth.

Nerve Supply.—The mylo-hyoid nerve, a branch of the inferior dental.

Dissection.—After the mylo-hyoid has been examined, it should be cut away from its origin and insertion, and completely removed. The view of the next muscles would also be improved by dividing the lower jaw a little to the side of the symphysis, and drawing it outwards ; or removing it altogether if the ramus have been already cut across in dissecting the internal pterygoid muscle. The tongue may then be drawn out of the mouth by means of a hook.

The **GENIO-HYOID** (γένειον, the chin) *arises* from a small tubercle on the inner side of the symphysis of the lower jaw, and is *inserted* into the body of the os hyoides. It is a short and slender muscle, closely connected with its fellow and with the border of the following.

Relations.—By its *superficial* or inferior *surface* with the mylo-hyoid ; by the *deep* or superior *surface* with the lower border of the genio-hyo-glossus.

Nerve Supply.—The hypoglossal nerve.

The **GENIO-HYO-GLOSSUS** (γλῶσσα, the tongue) is a triangular muscle, narrow and pointed at its origin from the lower jaw, broad

and fan-shaped at its attachment to the tongue. It *arises* from a tubercle above that of the genio-hyoid, and spreads out to be *inserted* into the whole length of the tongue, from base to apex, and into the body of the os hyoides.

Relations.—By its *inner surface* with its fellow of the opposite side. By its *outer surface* with the mylo-hyoid, hyo-glossus, stylo-glossus, lingualis, sublingual gland, lingual artery, gustatory nerve, and hypoglossal nerve. By its *upper border* with mucous membrane

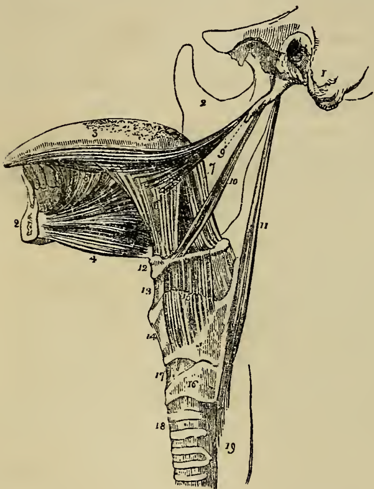


FIG. 184. — Styloid muscles and muscles of the tongue. 1. Temporal bone of the left side. 2, 2. The right side of the lower jaw, divided at its symphysis, the left side having been removed. 3. Tongue. 4. Genio-hyoid. 5. Genio-hyo-glossus. 6. Hyo-glossus; its basio-glossus portion. 7. Its cerato-glossus portion. 8. Anterior fibres of the lingualis issuing from between the hyo-glossus and genio-hyo-glossus. 9. Stylo-glossus, with part of the stylo-maxillary ligament. 10. Stylo-hyoid. 11. Stylo-pharyngeus. 12. Os hyoides. 13. Thyro-hyoid membrane. 14. Thyroid cartilage. 15. Thyro-hyoid muscle arising from the oblique line of the thyroid cartilage. 16. Cricoid cartilage. 17. Crico-thyroid membrane, through which the operation of laryngotomy is performed. 18. Trachea. 19. Commencement of the œsophagus.

of the floor of the mouth, in the situation of the frænum linguæ; by its *lower border* with the genio-hyoid.

Nerve Supply.—The hypoglossal nerve.

Actions.—All the members of this group of muscles act on the os hyoides when the lower jaw is fixed, and on the lower jaw when the os hyoides is drawn downwards and fixed by its depressor muscles. They act therefore as depressors of the jaw or as elevators of the hyoid bone. The genio-hyo-glossus is, moreover, a muscle of the tongue; its action upon that organ will be considered with the next group.

Fourth Group.—Muscles of the Tongue.

Genio-hyo-glossus, Lingualis,
Hyo-glossus, Stylo-glossus,
Palato-glossus.

Dissection.—These are already exposed by the preparation we have just made; there remains, therefore, only to dissect and examine them.

The **genio-hyo-glossus**, the first of these muscles, has been described with the last group.

The **HYO-GLOSSUS** is a square-shaped plane of muscle, *arising* from the whole length of the great cornu, the lesser cornu, and side of the body of the os hyoides; and *inserted* between the stylo-glossus and lingualis into the side of the tongue. The direction of the fibres which arise from the body is obliquely backwards; those from the great cornu pass obliquely forwards; hence they are described by Albinus as two muscles, under the names of *basio-glossus* and *cerato-glossus*, to which he added a third fasciculus, arising from the lesser cornu, and spreading along the side of the tongue, the *chondro-glossus*. The basio-glossus slightly overlaps the upper part of the cerato-glossus, and is separated from it by the transverse portion of the stylo-glossus.

Relations.—By its *external surface* with the digastric, stylo-hyoid, stylo-glossus, mylo-hyoid, gustatory nerve, hypoglossal nerve, Wharton's duct, and sublingual gland. By its *internal surface* with the middle constrictor of the pharynx, lingualis, genio-hyo-glossus, lingual artery, and glosso-pharyngeal nerve.

Nerve Supply.—The hypoglossal nerve.

The **LINGUALIS.**—The fibres of this muscle (lingualis longitudinalis inferior) may be seen towards the apex of the tongue, issuing from the interval between the hyo-glossus and genio-hyo-glossus; and is best examined by removing the preceding muscle. It consists of a small fasciculus of fibres running longitudinally from the base, where it is attached to the os hyoides, to the apex of the tongue. By the outer border its fibres reach the plane of longitudinal fasciculi of the stylo-glossus and lingualis superficialis; and by its under surface, it is in relation with the ranine artery.

The other muscles entering into the structure of the tongue, are the lingualis longitudinalis superior vel superficialis, and the lingualis transversus. The *lingualis superior* forms a thin plane on the upper surface of the organ, lying immediately beneath the mucous membrane. This layer is thicker in front than behind, and is covered posteriorly by a thin stratum of transverse fibres derived from the hyo-glossus. The *lingualis transversus* constitutes the chief bulk of the tongue; it lies between the lingualis superior and inferior, its fibres being attached at the middle line to the fibro-cartilaginous septum of the tongue, and laterally to the mucous membrane; some of its fibres are continuous with those of the stylo-glossus and hyo-glossus, and others are connected with the lesser cornua of the os hyoides. The fibres of the muscular structure of the tongue are separated from each other by a large quantity of very fine fat and some glandular tissue. The lateral halves of the tongue are divided by a distinct fibrous septum, which is sufficiently complete to prevent anastomosis of the arteries of one side with those of the other.

Nerve Supply.—The several layers of muscular fibre which constitute the lingualis muscle are chiefly supplied by the hypoglossal nerve, but some filaments of the facial also reach them.

The **STYLO-GLOSSUS** *arises* from the apex of the styloid process and from the stylo-maxillary ligament; it divides on the side of the tongue into two parts, one transverse, which passes transversely inwards between the two portions of the hyo-glossus, and is lost among the transverse fibres of the substance of the tongue—the other longitudinal, which spreads out upon the side of the tongue, and is prolonged forwards with the lingualis as far as its tip.

Relations.—By its *external surface* with the internal pterygoid muscle, gustatory nerve, parotid gland, sublingual gland, and mucous membrane of the floor of the mouth. By its *internal surface* with the tonsil, superior constrictor of the pharynx, and hyo-glossus.

Nerve Supply.—The hypoglossal and facial nerves.

The **PALATO-GLOSSUS** passes between the soft palate and the side of the base of the tongue, forming a prominence of the mucous membrane, which is called the anterior pillar of the fauces. Its fibres are spread out superiorly among the muscular fibres of the palato-pharyngeus, and inferiorly among the fibres of the stylo-glossus upon the side of the tongue. This muscle with its fellow constitutes the *constrictor isthmi faucium.*

Nerve Supply.—This muscle is supplied by branches from Meckel's ganglion and the pharyngeal plexus; the motor filaments being ultimately traceable to the facial.

Actions.—The genio-hyo-glossus muscle effects several movements of the tongue. When the tongue is steadied and pointed by the other muscles, the posterior fibres of the genio-hyo-glossus would dart it from the mouth, while its anterior fibres would restore it to its former position. The whole length of the muscle acting on the tongue, would render it concave along the middle line, and form a channel for the current of fluid towards the pharynx, as in sucking. The apex of the tongue is directed to the roof of the mouth, and rendered convex from before backwards by the linguales. The hyo-glossi, by drawing down the sides of the tongue, render it convex along the middle line. It is drawn upwards at its base by the palato-glossi, and backwards or to either side by the stylo-glossi. Thus the whole of the complicated movements of the tongue may be explained, by reasoning on the direction of the fibres of the muscles, and their probable actions. The palato-glossi muscles, assisted by the uvula, have the power of closing the fauces completely, an action which takes place in deglutition.

Fifth Group.—Muscles of the Pharynx.

Inferior constrictor,	Stylo-pharyngeus,
Middle constrictor,	Palato-pharyngeus.
Superior constrictor,	

Dissection.—To dissect the pharynx, the trachea and œsophagus are to be cut through at the lower part of the neck, and drawn upwards by dividing the loose cellular tissue which connects the

back of the pharynx with the vertebral column. The saw is then to be applied behind the styloid processes, and the base of the skull sawn through. The vessels and loose structures should be removed

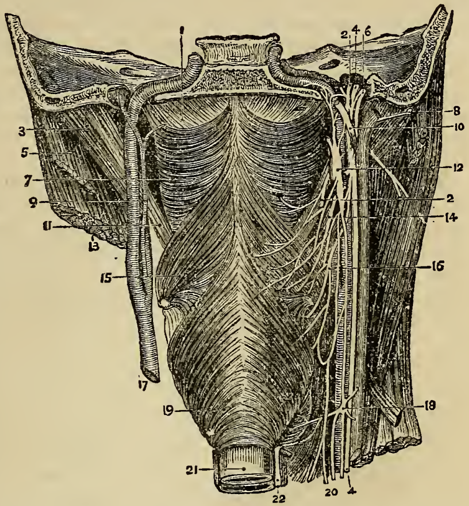


Fig. 185.—Dissection of the constrictor muscles of the pharynx with the vessels and nerves in relation with them. 1. Pharyngeal aponeurosis. 2, 2. Glosso - pharyngeal nerve. 3. Posterior belly of digastric. 4, 4. Pneumogastric nerve. 5. Splenius capitis. 6. Spinal - accessory nerve. 7. Superior constrictor muscle. 8. Internal jugular vein. 9. Ascending pharyngeal artery. 10. Hypoglossal nerve. 11. Stylo - pharyngeus. 12. Superior ganglion of sympathetic. 13. Sterno-mastoid. 14. Pharyngeal branch of pneumogastric. 15. Middle constrictor. 16. Superior laryngeal nerve. 17. Common carotid artery. 18. Middle ganglion of sympathetic. 19. Inferior constrictor. 20. Cardiac nerves. 21. Œsophagus. 22. Recurrent laryngeal nerve.

from the preparation, and the pharynx stuffed with tow or wool for the purpose of distending it, and rendering the muscles more easy of dissection.

Fascia.—The *pharyngeal fascia* or *aponeurosis* is a strong sheet situated between the muscles and mucous membrane; it is especially strong at its upper part, where it fills in the interval left above the festooned upper margin of the superior constrictor, and is attached to the basilar process of the occipital bone and petrous portion of the temporal. As it passes down it gradually becomes thinner, and at the lower part of the pharynx is distinguishable only as a layer of connective tissue uniting the mucous and muscular coats.

The **constrictors of the pharynx** are web-like sheets of muscle with fibres differently disposed, which form a muscular bag attached to the base of the skull. This bag communicates in front with the mouth. Each of the constrictors may be described as having one posterior attachment and three lateral.

The superior is attached to the tendinous raphé which hangs from the pharyngeal tubercle of the basilar process of the occipital bone; its lateral attachments are the internal pterygoid plate—the pterygo-maxillary ligament, and the mylo-hyoid ridge of the lower jaw. The middle is in like manner attached to the tendinous raphé, and

its lateral attachments are the greater and lesser cornua of the hyoid bone and the stylo-hyoid ligament. The inferior is attached to the tendinous raphé, its lateral attachments are the thyroid and cricoid cartilages and the upper ring of the trachea.

Their more particular description is as follows:—

The **INFERIOR CONSTRICTOR**, the thickest of the three constrictor muscles, *arises* from the upper ring of the trachea, the cricoid cartilage, and the oblique line of the thyroid. Its fibres spread out, and are *inserted* into the middle line of the pharynx, the inferior fibres being almost horizontal, the superior oblique and overlapping the middle constrictor.

Relations.—By its *external surface* with the vertebral column, longus colli, sheath of the common carotid artery, sterno-thyroid muscle, thyroid gland, and some lymphatic glands. By its *internal surface* with the middle constrictor, stylo-pharyngeus, palato-pharyngeus, and mucous membrane of the pharynx. By its *lower border*, near the cricoid cartilage, it is in relation with the recurrent nerve; and by the *upper border* with the superior laryngeal nerve. The

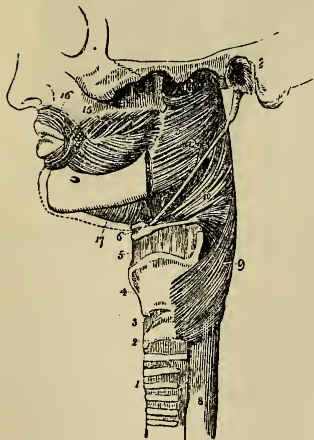


Fig. 186.—Side view of the muscles of the pharynx. 1. Trachea. 2. Cricoid cartilage. 3. Crico-thyroid membrane. 4. Thyroid cartilage. 5. Thyro-hyoid membrane. 6. Os hyoides. 7. Stylo-hyoid ligament. 8. Œsophagus. 9. Inferior constrictor. 10. Middle constrictor. 11. Superior constrictor. 12. Stylo-pharyngeus, passing down between the superior and middle constrictor. 13. Upper concave border of superior constrictor; at this point the muscular fibres of the pharynx are deficient. 14. Pterygo-maxillary ligament. 15. Buccinator. 16. Orbicularis oris. 17. Mylo-hyoid.

fibres of origin of this muscle are blended with those of the sterno-thyroid, thyro-hyoid, and crico-thyroid, and it frequently forms a tendinous arch across the latter; inferiorly it is blended with the circular fibres of the œsophagus.

The muscle must be removed before the next can be examined.

The **MIDDLE CONSTRICTOR** *arises* from the great cornu of the os hyoides, from the lesser cornu, and from the stylo-hyoid ligament. It radiates from its origin, and spreads out upon the side of the pharynx, the lower fibres descending and being overlapped by the inferior constrictor; the upper fibres ascending, so as to cover in the superior constrictor. It is *inserted* into the *raphé* of the pharynx,

and by a fibrous aponeurosis into the basilar process of the occipital bone. It is separated from the superior constrictor by the glosso-pharyngeal nerve and stylo-pharyngeus muscle, and from the inferior constrictor by the superior laryngeal nerve.

Relations.—By its *external surface* with the vertebral column, longus colli, rectus anticus major, carotid vessels, inferior constrictor, hyo-glossus, lingual artery, pharyngeal plexus of nerves, and some lymphatic glands. By its *internal surface*, with the superior constrictor, stylo-pharyngeus, palato-pharyngeus, and mucous membrane of the pharynx.

The upper portion of this muscle must be turned down, to bring the whole of the superior constrictor into view; in so doing, the stylo-pharyngeus muscle will be seen passing behind its upper border.

The **SUPERIOR CONSTRICTOR** is a thin and quadrilateral plane of muscular fibres *arising* from the side of the tongue, the extremity of the molar ridge of the lower jaw, the pterygo-maxillary ligament, and lower third of the posterior margin of the internal pterygoid plate; and *inserted* into the *raphé* of the pharynx and basilar process of the occipital bone. Its superior fibres are arched, leaving a concave interspace between its upper border and the basilar process; some of its lower fibres are continuous with those of the genio-hyo-glossus on the side of the tongue, and it is overlapped inferiorly by the middle constrictor.

Relations.—By its *external surface* with the vertebral column and muscles of the latter, behind; with the vessels and nerves contained in the *maxillo-pharyngeal space* laterally, and with the middle constrictor, stylo-pharyngeus, and tensor palati. By its *internal surface* with the levator palati, palato-pharyngeus, tonsil, and mucous membrane of the pharynx.

Nerve Supply.—The constrictor muscles of the pharynx are supplied by a plexus of nerves derived from the superior laryngeal and pharyngeal branches of the pneumogastric, the glosso-pharyngeal, and cervical plexus, mixed with some fibres from the sympathetic.

Maxillo-Pharyngeal Space.—Between the side of the pharynx and ramus of the lower jaw is a triangular interval, the *maxillo-pharyngeal space*, which is bounded at the *inner* side by the superior constrictor muscle; at the *outer* side by the internal pterygoid muscle; and *behind* by the rectus anticus major and vertebral column. In this space are situated the internal carotid artery, internal jugular vein, glosso-pharyngeal, pneumogastric, spinal accessory, and hypoglossal nerves.

The **STYLO-PHARYNGEUS** is a long and slender muscle *arising* from the inner side of the base of the styloid process; it descends between the superior and midde constrictor muscle, and spreads out beneath the mucous membrane of the pharynx; it is *inserted* partly into the posterior border of the thyroid cartilage and partly into the internal face of the inferior constrictor.

Relations.—By its *external surface* with the stylo-glossus muscle, external carotid artery, parotid gland, and middle constrictor. By its *internal surface* with the internal carotid artery, internal jugular vein, superior constrictor, palato-pharyngeus, and mucous membrane. Along its lower border is seen the glosso-pharyngeal nerve, which crosses it opposite the root of the tongue, to pass between the superior and middle constrictor and behind the hyo-glossus.

Nerve Supply.—This muscle is supplied by the glosso-pharyngeal nerve.

Associated in function with the preceding is a small muscle, not always present, the **salpingo*-pharyngeus** (levator pharyngeus internus), which *arises* from the lower border of the Eustachian tube near its aperture, and passes down upon the inner surface of the side of the pharynx, where it becomes united with the palato-pharyngeus.

The **palato-pharyngeus** is described with the muscles of the soft palate. It *arises* from the soft palate, and is *inserted* into the inner surface of the pharynx, and posterior border of the thyroid cartilage.

Actions.—The three constrictor muscles are important agents in deglutition ; they contract upon the morsel of food as soon as it is received by the pharynx, and convey it downwards into the œsophagus. The stylo-pharyngei draw the pharynx upwards, and widen it laterally. The palato-pharyngei also draw it upwards, and with the aid of the uvula close the opening of the fauces. The salpingo-pharyngei are elevators of the upper part of the pharynx. A more complete description of the mechanism of delgutition will be given after the palate muscles have been described.

Sixth Group.—Muscles of the Soft Palate.

Levator palati,	Palato-glossus,
Tensor palati,	Palato-pharyngeus.
Azygos uvulæ,	

Dissection.—To examine these muscles, the pharynx must be opened from behind by a vertical incision, and the mucous membrane carefully removed from off the posterior surface of the soft palate.

The **LEVATOR PALATI**, a moderately thick muscle, *arises* from the extremity of the petrous bone in front of the opening of the carotid canal, and from the posterior and inferior aspect of the cartilage of the Eustachian tube, and passing down by the side of the posterior nares spreads out between the fasciculi of origin of the palato-pharyngeus ; it is *inserted* into the middle line, where it is continuous with the muscle of the opposite side, and is overlaid by the azygos uvulæ. In order to reach the palate it passes through the opening above the superior constrictor muscle.

* σάλπιγξ, a tube.

Relations.—*Externally* with the tensor palati and superior constrictor muscle ; *internally* and *posteriorly* with the mucous membrane of the pharynx and soft palate ; inferiorly it passes between the two fasciculi of origin of the palato-pharyngeus to reach its insertion.

Nerve Supply.—Branches from Meckel's ganglion, the motor root of which is the facial nerve.

Dissection.—This muscle must be turned down from its origin on one side, and removed, and the superior constrictor dissected away from its pterygoid origin, to bring the next muscle into view.

The **TENSOR PALATI** (circumflexus) is a slender and flattened muscle ; it *arises* from the scaphoid fossa at the base of the internal pterygoid plate, from the spinous process of the sphenoid bone, the edge of the tympanic plate of the temporal bone, and from the anterior aspect of the Eustachian tube. It lies between the internal pterygoid muscle and internal pterygoid plate ; the tendon winds around the hamular process of the latter, and expands into an aponeurosis, which is *inserted* into the transverse ridge on the horizontal portion of the palate bone, and at the middle line is continuous with the aponeurosis of the opposite muscle. The tendon as it passes round the hamular process is contained in a synovial sheath.

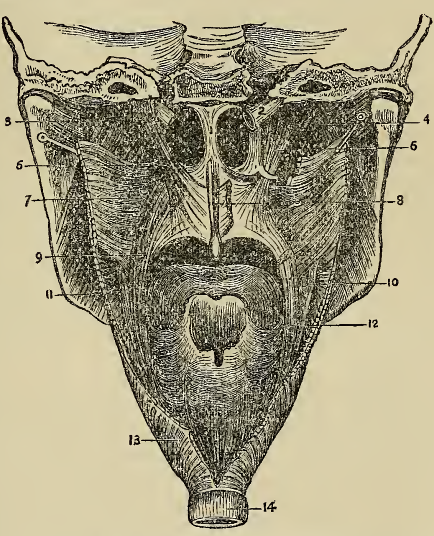


FIG. 187.—Muscles of the palate. 1. Septum narium. 2. Eustachian tube. 3. Pterygoideus externus. 4. Pterygoideus internus. 5. Levator palati. 6. Tensor palati. 7. Superior constrictor of pharynx. 8. Azygos uvulæ. 9. Palato-pharyngeus. 10. Stylo-pharyngeus. 11. Middle constrictor of pharynx. 12. Palato-pharyngeus (cut). 13. Inferior constrictor of pharynx. 14. Œsophagus.

Relations.—By its *external surface* with the internal pterygoid muscle ; by its *internal surface* with the levator palati, internal pterygoid plate, and superior constrictor. In the soft palate, its tendinous expansion is placed in front of the other muscles, and in contact with the mucous membrane.

Nerve Supply.—From the otic ganglion, the motor root of which is the facial nerve.

The **AZYGOS UVULÆ** is a pair of small muscles situated along the mid line of the soft palate. They *arise* from the spine of the palate bone, and aponeurosis of the soft palate, and are *inserted* into the uvula. By their anterior surface they are in relation with the levatores palati, palato-glossi, and anterior fasciculus of the palato-pharyngei; posteriorly they have the thin posterior fasciculus of the palato-pharyngei and the mucous membrane.

Nerve Supply.—Probably from Meckel's ganglion, the nerve fibres being, however, ultimately traceable to the facial nerve.

Dissection.—The two next muscles are brought into view by raising the mucous membrane from off the pillars of the soft palate at each side.

The **PALATO-GLOSSUS** (constrictor isthmi faucium) is a small fasciculus of fibres, which *arises* in the soft palate as a radiated expansion continuous with its fellow of the opposite side; and descends to be *inserted* into the side of the tongue. It is the prominence of this small muscle, covered by mucous membrane, that constitutes the anterior pillar of the soft palate. It has been named constrictor isthmi faucium, from a function it performs in common with the palato-pharyngeus—viz., constricting the opening of the fauces.

The **PALATO-PHARYNGEUS** (constrictor isthmi faucium posterior) forms the posterior pillar of the fauces; it *arises* by two fasciculi from the raphé of the soft palate, where its fibres are continuous with those of the muscle of the opposite side; and is *inserted* into the inner surface of the pharynx and posterior border of the thyroid cartilage. This muscle is broad above where it forms the whole thickness of the lower half of the soft palate, narrow in the posterior pillar, and again broad and thin in the pharynx where it spreads out previously to its insertion. The levator palati passes to its insertion between the two fasciculi of origin of this muscle.

Relations.—In the soft palate it is in relation with the mucous membrane both by its *anterior* and *posterior* surface; *above*, with the levator palati, and *below*, with the mucous glands situated along the margin of the arch of the palate. In the posterior pillar, it is surrounded for two-thirds of its extent by mucous membrane. In the pharynx, it is in relation by its *outer surface* with the superior and middle constrictor muscle, by its *inner surface* with the mucous membrane.

Nerve Supply.—The palato-glossus is supplied by the facial nerve, and the palato-pharyngeus from Meckel's ganglion and the pharyngeal plexus.

Actions.—The azygos uvulæ shortens the uvula. The levator palati raises the soft palate, while the tensor spreads it out laterally so as to form a septum between the pharynx and posterior nares. The palato-glossus and palato-pharyngeus constrict the opening of the fauces, and drawing down the soft palate, serve to press the mass of food from the dorsum of the tongue into the pharynx. The action of the levator and tensor palati muscles on the Eustachian tube will

be discussed when that structure is itself described along with the middle ear in Part VI. of this work.

Mechanism of Deglutition.—Deglutition is performed by means of the tongue and the muscles of the soft palate, fauces, and pharynx. The food bolus is pushed towards the fauces by the application of the tongue to the hard palate, the base of the tongue being also carried upwards and backwards by the action of the stylo-glossus muscles; in this way the bolus is caused to pass between the anterior pillars of the fauces the muscles of which (the palato-glossi) contract upon it. The palato-pharyngeus muscles forming the posterior pillars of the fauces also contract and narrow the faucial opening, the interval between them being filled up by the uvula; the tensor palati muscles make tense, and the levator palati draw upwards and backwards the soft palate till it nearly touches the posterior wall of the pharynx, thus preventing the food from passing upwards to the nasal cavity. At the same time the larynx is drawn upwards beneath the lower jaw by the elevator muscles of the os hyoides, and the thyroid cartilage is carried beneath the hyoid bone by the thyro-hyoid muscles so as to allow the epiglottis to fall over the upper opening of the larynx, this being facilitated by the tongue being carried backwards and the glosso-epiglottic folds rendered lax. The food, being thus prevented from passing into the nose or larynx, is thrown into the grasp of the constrictors of the pharynx, which successively contract upon it from above downwards, so as to pass it into the upper part of the œsophagus.

Seventh Group.—Prævertebral Muscles.

Rectus anticus major,	Scalenus medius,
Rectus anticus minor,	Scalenus posticus,
Scalenus anticus,	Longus colli.

Dissection.—These muscles have already been exposed by the removal of the pharynx from the anterior aspect of the vertebral column; all that is further needed is the removal of the fascia by which they are invested.

The **RECTUS ANTICUS MAJOR**, broad and thick above, narrow and pointed below, *arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ; and is *inserted* into the basilar process of the occipital bone.

Relations.—By its *anterior surface* with the pharynx, internal carotid artery, internal jugular vein, superior cervical ganglion and trunk of the sympathetic nerve, pneumogastric, and spinal accessory nerve. By its *posterior surface* with the rectus anticus minor, and superior cervical vertebræ; *internally* with the longus colli, and *externally* with the scaleni.

Nerve Supply.—Anterior branch of the first cervical nerve.

The **RECTUS ANTICUS MINOR** *arises* from the anterior

border of the lateral mass of the atlas, and is *inserted* into the basilar process; its fibres being directed obliquely upwards and inwards.

Relations.—By its *anterior surface* with the rectus anticus major, and superior cervical ganglion of the sympathetic. By its *posterior surface* with the articulation of the condyle of the occipital bone with the atlas, and anterior occipito-atlantal ligament.

Nerve Supply.—Anterior branch of the first cervical.

The **SCALENUS ANTICUS** is a triangular muscle, as its name implies, situated at the root of the neck, and appearing like a continuation of the rectus anticus major; it *arises*, by a flat and narrow tendon, from a tubercle on the upper and inner border of the first rib; and is *inserted* into the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ.

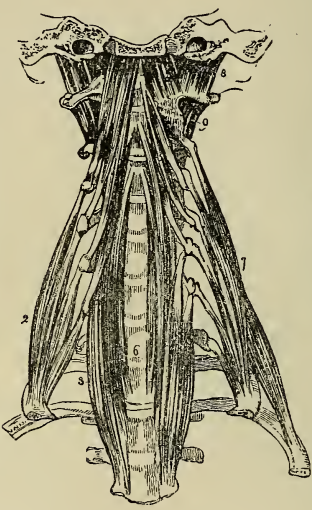


Fig. 188.—Prævertebral group of muscles of the neck. 1. Rectus anticus major. 2. Scalenus anticus. 3. Lower oblique part of the longus colli of the right side; it is concealed superiorly by the rectus anticus major. 4. Rectus anticus minor. 5. Upper oblique portion of the longus colli. 6. Its vertical portion; the figure rests on the seventh cervical vertebra. 7. Scalenus medius; behind which is seen the scalenus posticus. 8. Rectus lateralis, left side. 9. One of the intertransversales.

Relations. — By its *anterior surface* with the sterno - mastoid, subclavius, omo-hyoid, supra-scapular, ascending cervical and transversalis colli arteries, phrenic nerve, and subclavian vein, by which latter it is separated from the subclavius muscle and clavicle. By its *posterior surface* with the pleura, the nerves which form the brachial plexus, and below, the subclavian artery. By its *inner side* with the longus colli, being separated by the vertebral artery; by its *outer side* with the scalenus medius. Its relations with the subclavian artery and vein are important, the vein being before, the artery behind the muscle.

Nerve Supply.—Branches of the lower cervical nerves.

The **SCALENUS MEDIUS**, the largest of the three, *arises* from the first rib between the groove of the subclavian artery and the tubercle, and is *inserted* by separate tendons into the posterior tubercles of the transverse processes of all the cervical vertebræ excepting the first.

Relations.—By its *anterior surface* with the brachial plexus and subclavian artery; *posteriorly* with the scalenus posticus, levator

anguli scapulæ, and cervicalis ascendens ; *internally* with the pleura, inter-transverse muscles, and cervical vertebræ ; *externally* with the sterno-mastoid, omo-hyoid, supra-scapular and transversalis colli artery. It is separated from the scalenus anticus by the subclavian artery below and cervical nerves above.

Nerve Supply.—Branches of the lower cervical nerves.

The **SCALENUS POSTICUS**, of small size, *arises* by a thin tendon from the second rib between its tubercle and angle, and divides superiorly into two or three tendons, which are *inserted* into the posterior tubercles of the transverse processes of the two or three

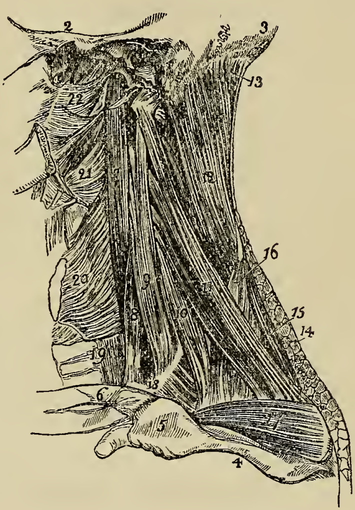


FIG. 189.—Lateral view of the muscles of the prævertebral region and side of the neck. 1. The mastoid process of the temporal bone. 2. The zygoma. 3. The occipital bone. 4. The spine of the scapula. 5. The acromion process. 6. The clavicle. 7. The longus colli muscle. 8. Scalenus anticus. 9. Scalenus medius. 10. Scalenus posticus. 11. Levator anguli scapulæ. 12. Splenius. 13. Complexus. 14. Cut edge of the trapezius. 15. Rhomboideus minor. 16. Serratus posticus superior. 17. Supra-spinatus. 18. Opening between the scalenus anticus and medius for the subclavian artery ; the number is placed on the first rib ; and the fibres below it are those of the first intercostal muscle. 19. Œsophagus and trachea. 20. Inferior constiictor of pharynx. 21. Middle constrictor. 22. Superior constrictor.

lower cervical vertebræ. The scalenus posticus was formerly described with the scalenus medius as one muscle ; while Albinus and Sœmmerring make five scaleni.

Relations.—In *front* with the scalenus medius ; *behind* with the two upper levatores costarum and cervicalis ascendens.

Nerve Supply.—Branches from the brachial and cervical plexus.

The **LONGUS COLLI** is a long and flat muscle, consisting of three portions, two oblique and one vertical. The *superior oblique* portion *arises* from the anterior tubercle of the atlas, and is *inserted* into the anterior tubercles of the transverse processes of the third, fourth, and fifth cervical vertebræ. The *inferior oblique* portion *arises* from the transverse processes of the fifth and sixth cervical vertebræ, and passes down the neck to be *inserted* into the bodies of the two or three upper dorsal vertebræ. The *vertical* portion *arises*

from the bodies of the second, third, and fourth cervical vertebræ, and is *inserted* into the bodies of the three lower cervical and three upper dorsal vertebræ. We may thus arrange these attachments in a tabular form :—

	Origin.	*Insertion.*
Upper oblique portion.	Atlas	3d, 4th, and 5th cervical transverse processes.
Lower oblique portion.	5th and 6th cervical transverse processes.	3 upper dorsal, bodies.
Vertical portion.	2d, 3d, and 4th cervical bodies.	3 lower cervical and 3 upper dorsal, bodies.

In general terms, the muscle is attached to the bodies and transverse processes of the six superior cervical vertebræ above, and to the bodies of the last three cervical and first three dorsal below.

Relations.—By its *anterior surface* with the pharynx, œsophagus; sheath of the common carotid, internal jugular vein and pneumogastric nerve; sympathetic nerve, inferior laryngeal nerve, and inferior thyroid artery. By its *posterior surface* it rests on the cervical and upper dorsal vertebræ.

Nerve Supply.—Brachial plexus.

Actions.—The rectus anticus major and minor preserve the equilibrium of the head upon the atlas; and acting with the longus colli, flex and rotate the head and the cervical portion of the vertebral column. The scaleni muscles are flexors of the vertebral column; and, acting from above, fix the first and second ribs for the inspiratory muscles.

Eighth Group.—Muscles of the Larynx.

These muscles are described with the anatomy of the larynx, in Part VII.

MUSCLES AND FASCIÆ OF THE TRUNK.

The muscles of the trunk may be subdivided into four natural groups, viz. :—

1. Muscles of the back.
2. Muscles of the thorax.
3. Muscles of the abdomen.
4. Muscles of the perinæum.

1. **Muscles of the Back.**—The *region of the back*, in consequence of its extent, is common to the neck, upper extremities, and abdo-

men: and its muscles, which are numerous, may be arranged into six layers.

First Layer.

Trapezius,
Latissimus dorsi.

Second Layer.

Levator anguli scapulæ,
Rhomboideus minor,
Rhomboideus major.

Third Layer.

Serratus posticus superior,
Serratus posticus inferior,
Splenius capitis,
Splenius colli.

Fourth Layer.

(Dorsal Group.)

Sacro-lumbalis,
Musculus accessorius,
Longissimus dorsi,
Spinalis dorsi.

(Cervical Group.)

Cervicalis ascendens,
Transversalis cervicis,
Trachelo-mastoid,
Complexus.

Fifth Layer.

(Dorsal Group.)

Semi-spinalis dorsi,
Semi-spinalis colli.

(Cervical Group.)

Rectus posticus major,
Rectus posticus minor,
Rectus lateralis,
Obliquus inferior,
Obliquus superior.

Sixth Layer.

Multifidus spinæ,
Rotatores spinæ,
Inter-spinales,
Inter-transversales,
Levatores costarum.

First Layer.

Dissection.—The muscles of this layer are to be dissected by making an incision along the middle line of the back, from the tubercle on the occipital bone to the coccyx. From the upper point of this incision carry a second transversely outwards to the back of the ear; inferiorly an incision must be made from the extremity of the sacrum, along the crest of the ilium, to about its middle. For convenience of dissection, a fourth may be carried from the spine of the seventh cervical vertebra to the acromion process. The integument and superficial fascia, together, are to be dissected off the muscles in the course of their fibres, over the whole of this region.

The **TRAPEZIUS** muscle (*trapezium*, a quadrangle with unequal sides) *arises* from the inner third of the superior curved line of the occipital bone, from the ligamentum nuchæ, and from the supraspinous ligament and spinous processes of the last cervical and all the dorsal vertebræ. The fibres converge from these various points, the upper and lower being oblique, and the middle nearly horizontal, and are *inserted* into the scapular third of the clavicle, acromion process, and upper border of the spine of the scapula, as far back as

its tubercle. Over the two lower cervical and two upper dorsal spines the origin is markedly aponeurotic, so as to present the appearance of a tendinous ellipse. The lower fibres of the muscles terminate in a flattened tendon which plays over the smooth triangular area at the root of the spine of the scapula. When the trapezius is dissected on both sides, the two muscles resemble a trapezium, or diamond-shaped quadrangle, on the posterior part of the shoulders; hence the muscle was formerly named cucullaris (*cucullus*, a monk's cowl).

Relations.—By its *superficial surface* with the integument and superficial fascia, to which it is closely adherent by its cervical portion, loosely by its dorsal portion. By its *deep surface*, from above downwards, with the complexus, splenius, levator anguli scapulæ, supra-spinatus, rhomboideus minor, rhomboideus major, and small portions of the infra-spinatus, serratus posticus superior, latissimus dorsi and vertebral aponeurosis, the latter separating it from the erector spinæ. The *anterior border* of the cervical portion forms the posterior boundary of the posterior triangle of the neck. Its clavicular insertion sometimes advances to the middle of the clavicle, or as far as the outer border of the sterno-mastoid, and occasionally it has been seen to overlap the latter. This is a point to be borne in mind in the operation for ligature of the subclavian artery. The spinal accessory nerve passes beneath the anterior border, near the clavicle, previously to its distribution to the under surface of the muscle.

Nerve Supply.—Spinal accessory, and third and fourth cervical.

The **ligamentum nuchæ** is a thin fibrous band extended from the tubercle and spine of the occipital bone to the spinous process of the seventh cervical vertebra, where it is continuous with the supraspinous ligament. It is connected with the spinous processes of all the cervical vertebræ, excepting the atlas, by means of a series of small fibrous slips; and is the homologue of an important elastic ligament in animals.

The **LATISSIMUS DORSI** muscle covers the whole of the lower part of the back and loins. It *arises* from the spinous processes of the four or six inferior dorsal, and all the lumbar vertebræ, from the supraspinous ligament, spinous tubercles of the sacrum, posterior third of the crest of the ilium, and four lower ribs; the latter origin taking place by muscular slips, which indigitate with the external oblique muscle of the abdomen. The fibres from this extensive origin converge as they ascend, and cross the inferior angle of the scapula; they then curve around the lower border of the teres major muscle, and terminate in a short quadrilateral tendon, which gets in front of the tendon of the teres, and is *inserted* into the bicipital groove. The tendinous origin of the muscle is united by its under surface with the posterior lamella of the fascia lumborum, and forms the posterior part of the sheath of the erector spinæ; it is also connected with the posterior aponeurosis of the obliquus internus. A synovial bursa is interposed between its upper border and the lower

angle of the scapula, and another between the upper half of its tendon and that of the teres major; the two tendons being united inferiorly. The muscle frequently receives a small fasciculus from

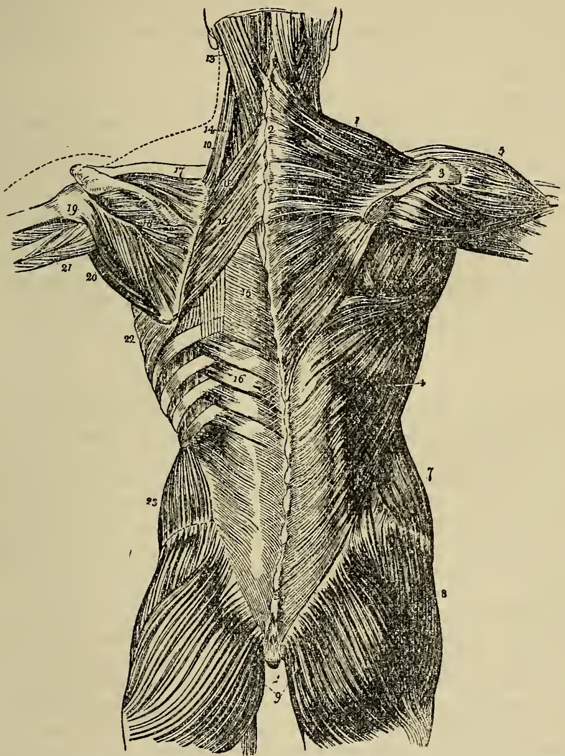


Fig. 190.—First, second, and part of the third layer of muscles of the back; the first layer occupies the right, the second, the left side. 1. Trapezius. 2. Tendinous portion, forming, with a corresponding part of the opposite muscle, the tendinous ellipse on the back of the neck. 3. Acromion process and spine of the scapula. 4. Latissimus dorsi. 5. Deltoid. 6. Muscles of the dorsum of the scapula: infra-spinatus, teres minor, and teres major. 7. Obliquus externus. 8. Gluteus medius. 9. Glutei maximi. 10. Levator anguli scapulæ. 11. Rhomboideus minor. 12. Rhomboideus major. 13. Splenius capitis; the muscle immediately above, and overlaid by the splenius, is the complexus. 14. Splenius colli, partially seen; the common origin of the splenius is seen attached to the spinous processes below the origin of the rhomboideus major. 15. Vertebral aponeurosis. 16. Serratus posticus inferior. 17. Supra-spinatus. 18. Infra-spinatus. 19. Teres minor. 20. Teres major. 21. Long head of triceps, passing between teres minor and major to the arm. 22. Serratus magnus. 23. Obliquus internus.

the scapula as it crosses its inferior angle; and sometimes by means of its tendon, a small muscular fasciculus from the pectoralis major; its tendon also gives off fibres to the deep fascia of the upper arm.

At the upper border of this muscle is a small triangular interval, bounded above by the lower border of the rhomboideus major, within by the trapezius, and below by the latissimus dorsi; in this space the ribs and intercostal muscles are seen to be uncovered by the muscles of the back.

Relations.—By its *superficial surface* with the integument and superficial fascia, the latter being dense and fibrous in the lumbar region, and with the trapezius. By its *deep surface*, from below upwards, with the erector spinæ, serratus posticus inferior, posterior aponeurosis of the obliquus internus, obliquus externus, serratus magnus, intercostal muscles and ribs, rhomboideus major, inferior angle of the scapula, and teres major. The latissimus dorsi, with the teres major, forms the posterior border of the axilla.

Nerve Supply.—By the long subscapular branch of the posterior cord of the brachial plexus, and by the posterior branches of the dorsal and lumbar nerves.

Second Layer.

Dissection.—This layer is brought into view by dividing the two preceding muscles near their insertion, and turning them aside.

The **LEVATOR ANGULI SCAPULÆ** *arises* by tendinous slips, from the posterior tubercles of the transverse processes of the four upper cervical vertebræ; and is *inserted* into the upper angle and posterior border of the scapula, as far as the triangular smooth surface at the root of its spine. Being the principal elevator of the shoulder, the levator anguli scapulæ has been termed *musculus patientiæ.*

Relations.—By its *superficial surface* with the trapezius, sterno-mastoid, and integument. By its *deep surface* with the splenius colli, transversalis cervicis, cervicalis ascendens, scalenus posticus and serratus posticus superior, and with the transversalis colli and posterior scapular arteries. The tendons of origin are interposed between the attachments of the scalenus medius in front and the splenius colli and transversalis cervicis behind.

Nerve Supply.—By the rhomboid branch of the brachial plexus, and branches from the second, third, and fourth cervical.

The **RHOMBOIDEUS MINOR** (*rhombus*, a parallelogram with four equal sides) is a narrow slip of muscle, detached from the rhomboideus major by a slight cellular interspace. It *arises* from the spinous processes of the last cervical and first dorsal vertebræ and ligamentum nuchæ; and is *inserted* into the edge of the triangular surface, on the posterior border of the scapula.

The **RHOMBOIDEUS MAJOR** *arises* from the spinous processes and supra-spinous ligaments of the four upper dorsal vertebræ, and is *inserted* into the posterior border of the scapula as far as its

inferior angle. The insertion is effected by means of a tendinous band, which is attached above to the triangular surface at the root of the spine, below, to the inferior angle, and between these points to the posterior border of the scapula by means of a thin membrane.

Relations.—By their *superficial surface* the rhomboid muscles are in relation with the trapezius, and the rhomboideus major with the latissimus dorsi and integument; by their *deep surface* with the serratus posticus superior, erector spinæ, posterior scapular artery, intercostal muscles and ribs.

Nerve Supply.—The rhomboid muscles are supplied by a branch of the brachial plexus called rhomboid; it is derived from the fifth cervical.

Third Layer.

Dissection.—The *third layer* consists of muscles which arise from the spinous processes of the vertebral column, and pass outwards. It is brought into view by dividing the levator anguli scapulæ near its insertion, and reflecting the two rhomboid muscles upwards from their insertion into the scapula. The latter muscles should now be removed.

The **SERRATUS POSTICUS SUPERIOR** is situated at the upper part of the thorax; it *arises* from the ligamentum nuchæ and spinous processes of the last cervical and two upper dorsal vertebræ. The muscle passes obliquely downwards and outwards, and is *inserted* by four serrations into the upper border of the second, third, fourth, and fifth ribs, a little beyond their angle.

Relations.—By its *superficial surface* with the trapezius, rhomboideus major and minor, and serratus magnus. By its *deep surface* with the splenius, erector spinæ, intercostal muscles and ribs.

The **SERRATUS POSTICUS INFERIOR** *arises* from the spinous processes and interspinous ligaments of the two lower dorsal and two or three upper lumbar vertebræ, and passing obliquely upwards, is *inserted* by four serrations into the lower border of the four inferior ribs. Both muscles consist of a thin aponeurosis for about half their extent.

Relations.—By its *superficial surface* with the latissimus dorsi, its tendinous origin being inseparably connected with the aponeurosis of that muscle. By its *deep surface* with the erector spinæ, intercostal muscles, and lower ribs. The *upper border* is continuous with a thin tendinous layer, the vertebral aponeurosis.

Nerve Supply.—The serrati muscles are supplied by the external branches of the posterior divisions of the dorsal nerves.

The **vertebral aponeurosis** (fascia lumbo-dorsalis) is a thin membranous expansion, composed of transverse and longitudinal fibres, extending from the upper border of the serratus posticus inferior upwards beneath the serratus posticus superior to the neck, where it is lost in the cervical fascia. It is attached along the middle line to the spinous processes of the dorsal vertebræ, externally

to the angles of the ribs, and forms the posterior boundary of a triangular sheath, which contains the erector spinæ and deep muscles of the back. The other two boundaries of the triangular sheath are the ribs and vertebræ in front and the spinous processes of the vertebræ at the middle line.

Dissection.—The serratus posticus superior must be removed from its origin and turned outwards, to bring into view the whole extent of the splenius muscle.

The **SPLENIUS** muscle is single at its origin, but divides soon after into two portions, which are destined to distinct insertions. It *arises* from the lower half of the ligamentum nuchæ, the spinous process of the last cervical, and spinous processes and interspinous ligaments of the six upper dorsal vertebræ; it divides as it ascends the neck into the splenius capitis and splenius colli.

The **splenius capitis** is *inserted* into the rough surface of the occipital bone beneath the superior curved line, and posterior border of the mastoid process of the temporal bone.

The **splenius colli** is *inserted* into the posterior tubercles of the transverse processes of the three upper cervical vertebræ.

The splenius is separated from its fellow of the opposite side by a triangular interval in which is seen the complexus.

Relations.—By its *superficial surface* with the trapezius, sterno-mastoid, levator anguli scapulæ, rhomboideus minor and major, and serratus posticus superior. By its *deep surface* with the spinalis dorsi, longissimus dorsi, semi-spinalis colli, complexus, trachelo-mastoid, and transversalis cervicis. The tendons of insertion of the splenius colli are interposed between and united with the tendons of the levator anguli scapulæ in front, and the transversalis cervicis behind.

Nerve Supply.—The great occipital, and the external branches of the posterior divisions of the cervical and five upper dorsal nerves.

Fourth Layer.

Dissection.—The two serrati and two splenii muscles must be removed by cutting them away from their origin and insertion, and the vertebral aponeurosis laid open, to bring the fourth layer into view.

Three of these muscles—viz., sacro-lumbalis, longissimus dorsi, and spinalis dorsi—are associated under the name of ERECTOR SPINÆ.* They occupy the lumbar and dorsal portion of the back. The remaining four are situated in the cervical region.

The **SACRO-LUMBALIS** and **LONGISSIMUS DORSI** *arise* by a common origin from the posterior third of the crest of the ilium, the oblique sacro-iliac ligament, articular and spinous tubercles of the sacrum, spinous processes of the lumbar vertebræ, and, deeply,

* Many anatomists include under the name of *erector spinæ* not only the sacro-lumbalis with its accessory portion, the longissimus dorsi, and the spinalis dorsi, but also the cervicalis ascendens, transversalis cervicis, and trachelo-mastoid.

from the transverse processes of the lumbar vertebræ; the external portion being fleshy, the internal tendinous. The tendinous portion is broad and flat, and gives origin by its deep surface to a considerable part of the muscular fibres. In the lumbar region, the muscle proceeding from this extensive origin is a broad and thick musculo-tendinous mass, on the surface of which, opposite the last rib, a line of separation is apparent, the outer portion, about one-third, being the sacro-lumbalis, the inner two-thirds the longissimus dorsi.

The **sacro-lumbalis** (ilio-costalis) ascends upon the chest internally to the angles of the ribs, and is *inserted* by separate slips, the four upper tendinous, the two lower fleshy, into the angles of the six lower ribs.

If this muscle be turned a little outwards, a number of tendinous slips will be seen which take their origin from the upper border of the ribs near their angles, and terminate in muscular fasciculi, which prolong the sacro-lumbalis to the upper part of the chest. This is the **musculus accessorius ad sacro-lumbalem**; it *arises* from the six lower ribs, and is *inserted* by separate tendons into the angles of the six upper ribs and transverse process of the seventh cervical vertebra.

The **longissimus dorsi** is *inserted* by two series of tendons, internal and external; the *internal* being implanted into the accessory and transverse processes of all the lumbar, and transverse processes of all the dorsal vertebræ; the *external* into the transverse processes of the lumbar vertebræ, and all the ribs, excepting the first, between their tubercles and angles.

The **SPINALIS DORSI** is situated at the inner side of the longissimus dorsi, and *arises* from the spinous processes of the two upper lumbar and two lower dorsal vertebræ; it is *inserted* into the spinous processes of the upper dorsal vertebræ from the second to the sixth or eighth. It also receives several fasciculi from the longissimus dorsi and semi-spinalis dorsi. The two muscles form an ellipse, which embraces the spinous processes of the dorsal vertebræ.

Relations.—The erector spinæ muscle is in relation by its *superficial surface* (in the lumbar region) with the serratus posticus inferior and latissimus dorsi; (in the dorsal region) with the vertebral aponeurosis, which separates it from the latissimus dorsi, trapezius, and serratus posticus superior, and with the splenius. By its *deep surface* (lumbar region) with the multifidus spinæ, transverse processes of the lumbar vertebræ, and middle layer of the lumbar fascia, which separates it from the quadratus lumborum; (dorsal region) with the multifidus spinæ, semi-spinalis dorsi, levatores costarum, intercostal muscles, and ribs as far as their angles. *Internally* or mesially, with the multifidus spinæ and semi-spinalis dorsi, which separates it from the spinous processes and arches of the vertebræ.

The fascia lumborum, with the spinal column, aponeurosis of the latissimus dorsi, and ribs, forms a complete osseo-aponeurotic sheath for the erector spinæ.

The **CERVICALIS ASCENDENS vel descendens** is the con-

tinuation of the sacro-lumbalis upwards into the neck. It *arises* from the angle of the third, fourth, fifth, and sixth ribs, and is *inserted* by slender tendons into the posterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ. The term *descendens*, applied to this muscle, can only be correct when it is described as arising in the neck and passing downwards to the ribs.

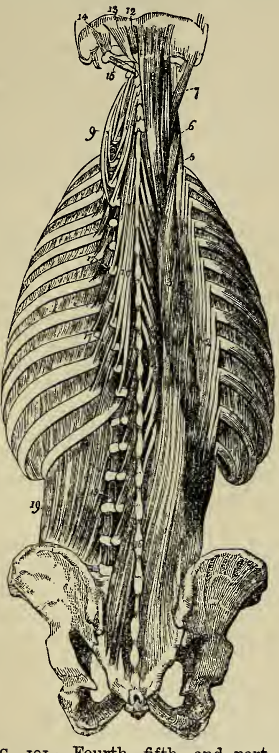


FIG. 191.—Fourth, fifth, and part of the sixth layer of the muscles of the back. 1. Common origin of the erector spinæ. 2. Sacro-lumbalis. 3. Longissimus dorsi. 4. Spinalis dorsi. 5. Cervicalis ascendens. 6. Transversalis cervicis. 7. Trachelo-mastoid. 8. Complexus. 9. Transversalis cervicis, showing its origin. 10. Semispinalis dorsi. 11. Semi-spinalis colli. 12. Rectus posticus minor. 13. Rectus posticus major. 14. Obliquus superior. 15. Obliquus inferior. 16. Multifidus spinæ. 17, 17. Levatores costarum. 18. Inter-transversales. 19. Quadratus lumborum.

Relations.—By its *superficial surface* with the levator anguli scapulæ; by its *deep surface* with the upper intercostal muscles, ribs, and intertransverse muscles; *externally* with the scalenus posticus and medius; *internally* with the transversalis cervicis. The tendons of insertion are interposed between the attachments of the scalenus medius and posticus and transversalis cervicis, with which they are united.

The **TRANSVERSALIS CERVICIS** appears to be the continuation upwards into the neck of the longissimus dorsi; it *arises* from the transverse processes of the five or six upper dorsal vertebræ, and is *inserted* into the posterior tubercles of the transverse processes of the cervical vertebræ, from the second to the sixth. It receives a fasciculus from the longissimus dorsi and several small slips from the trachelo-mastoid.

Relations.—By its *superficial surface* with the levator anguli scapulæ, splenius, and longissimus dorsi. By its *deep surface* with the complexus, trachelo-mastoid, and vertebræ; *externally* with the musculus accessorius ad sacro-lumbalem and cervicalis ascendens; *internally* with the trachelo-mastoid and complexus. The tendons of insertion of this muscle are interposed between the tendons of insertion of the cervicalis ascendens on the outer side, and those of origin of the trachelo-mastoid on the inner side.

The **TRACHELO-MASTOID** is likewise a continuation upwards from the longissimus dorsi. It is a slender and delicate muscle, *arising* from the transverse processes of the three upper dorsal and last cervical, and from the articular processes of the three next cervical vertebræ, its origin being similar to that of the complexus, with which and the origin of the transversalis cervicis it is closely connected. It receives a fasciculus from the longissimus dorsi, and is *inserted* into the posterior border and summit of the mastoid process.

Relations.—The same as the preceding muscle, excepting that it is interposed between the transversalis cervicis and complexus.

Nerve Supply.—This and the preceding muscles are supplied by the external branches of the posterior divisions of the dorsal and cervical nerves.

The **COMPLEXUS** is a large muscle, forming with the splenius the great bulk of the back of the neck. It crosses the direction of the splenius, *arising* from the transverse processes of the three upper dorsal and last cervical, and from the articular processes of the three next lower cervical vertebræ; and is *inserted* into the rough surface of the occipital bone between the two curved lines, as far as the occipital spine. The complexus is marked in the upper part of the neck by a transverse tendinous intersection.

A large fasciculus of the complexus lying superficially to the rest of the muscle, and remarkable for consisting of two fleshy bellies with an intermediate tendon, is usually described under the name of *biventer cervicis.* Considered as a separate muscle, it *arises* by three or four slips from the transverse processes of the dorsal vertebræ, from the fourth to the seventh; and is *inserted* into the inner portion of the superior curved line of the occipital bone. Its tendons of origin lie internally to the insertions of the longissimus dorsi, and are connected with those of the semi-spinalis colli; and its lower belly receives a fasciculus from the longissimus. The outer border of the upper belly is united with the complexus; in the rest of its course it is free.

Relations.—By its *superficial surface* with the trapezius, splenius, trachelo-mastoid, transversalis cervicis, and longissimus dorsi. By its *deep surface* with the semi-spinalis dorsi and colli, recti and obliqui. It is separated from its fellow of the opposite side by the ligamentum nuchæ, and from the semi-spinalis colli by the profunda cervicis artery, princeps cervicis branch of the occipital, and posterior cervical plexus of nerves.

Nerve Supply.—The great occipital, and internal branches of posterior divisions of the six lower cervical and five upper dorsal nerves.

The muscles of the fourth layer form the greater part of the muscular mass which fills up the great vertebral groove on each side of the spine; they are often described collectively under the name of erector spinæ; but this title should correctly be limited to the fleshy and tendinous mass which springs from the back of the pelvis and

the lumbar vertebræ. When the erector spinæ reaches the level of the last rib, the greater part of it divides to form two muscular columns, the outer receiving the name of sacro-lumbalis, the inner of longissimus dorsi; these are continued as they ascend into the muscles of the upper part of the back and neck, their relation to each other being indicated in the subjoined statement. To these two columns a third is added, forming the spinalis dorsi; it is placed the most internally of the three, and is limited to the dorsal and upper lumbar region.

Erector Spinæ.

Sacro-lumbalis,	Longissimus dorsi,	Spinalis dorsi.
Musculus accessorius,	Transversalis cervicis,	
Cervicalis ascendens.	Trachelo-mastoid.	

Fifth Layer.

Dissection.—The muscles of the preceding layer are to be removed by dividing them transversely through the middle, and turning one extremity upwards, the other downwards. In this way the whole of the muscles of the fourth layer may be dissected off, and the remaining muscles of the spine brought into a state to be examined.

The **SEMI-SPINALES MUSCLES** are connected with the transverse and spinous processes of the vertebræ, spanning one-half the vertebral column; hence their name, semi-spinales.

The **SEMI-SPINALIS DORSI** *arises* from the transverse processes of the dorsal vertebræ from the sixth to the tenth; and is *inserted* into the spinous processes of the four upper dorsal and two lower cervical vertebræ. It is united below with the spinalis dorsi, and above with the semi-spinalis colli; it also sends several small slips to the longissimus dorsi.

The **SEMI-SPINALIS COLLI**, larger than the preceding, *arises* from the transverse processes of the five or six upper dorsal vertebræ; and is *inserted* into the spinous processes of the cervical vertebræ from the second to the fifth.

Relations.—By their *superficial surface* the semi-spinales are in relation from below upwards with the spinalis dorsi, longissimus dorsi, complexus, splenius, profunda cervicis and princeps cervicis artery, and posterior cervical plexus of nerves. By their *deep surface* with the multifidus spinæ muscle.

Nerve Supply.—The semi-spinales are supplied by the internal branches of the posterior divisions of the dorsal and cervical nerves.

On the middle line in the cervical region is a small muscle, the

analogue of the spinalis dorsi, termed the *spinalis cervicis.* It is extremely irregular: *arising* from the spinous processes of the two upper dorsal or two lower cervical vertebræ; and *inserted* into the spinous process of the axis, and sometimes into the next one or two vertebræ.

Occipital Group.—This group of small muscles is intended for the movements of the cranium on the atlas, and atlas on the axis.

The **RECTUS CAPITIS POSTICUS MAJOR** (superficialis) *arises* from the spinous process of the axis, and is *inserted* into the inferior curved line of the occipital bone.

The **RECTUS CAPITIS POSTICUS MINOR** (profundus) *arises* from the spinous tubercle of the atlas, and is *inserted* into the rough surface of the occipital bone, beneath the inferior curved line.

The **RECTUS CAPITIS LATERALIS** *arises* from the transverse process of the atlas, and *inserted* into the rough surface of the occipital bone, externally to the condyle.

The **OBLIQUUS INFERIOR CAPITIS** (major) *arises* from the spinous process of the axis, and passes obliquely outwards to be *inserted* into the extremity of the transverse process of the atlas.

The **OBLIQUUS SUPERIOR CAPITIS** (minor) *arises* from the extremity of the transverse process of the atlas, and passes obliquely inwards to be *inserted* into the rough surface of the occipital bone, between the curved lines, and directly behind the mastoid process.

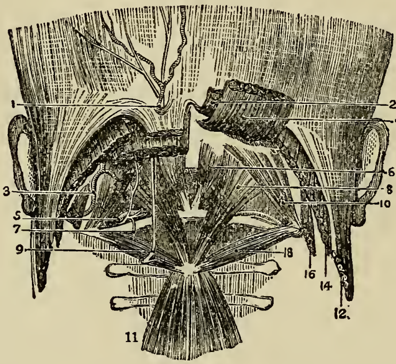


FIG. 192.—Suboccipital region. 1. Occipital artery and nerve piercing the trapezius. 2. Trapezius. 3. Occipital artery. 4. Complexus. 5. Vertebral artery. 6. Rectus capitis posticus minor. 7. Suboccipital nerve. 8. Rectus capitis posticus major. 9. Great occipital nerve. 10. Obliquus superior. 11. Semi-spinalis colli. 12. Sterno-mastoid. 14. Splenius capitis. 16. Trachelo-mastoid. 18. Obliquus inferior.

Relations.—By their *superficial surface* the recti and obliqui are in relation with a strong aponeurosis which separates them from the complexus. By their *deep surface* with the atlas and axis. The rectus posticus major partly covers in the rectus minor. The rectus lateralis is in relation by its *anterior surface* with the internal jugular vein, and by its *posterior surface* with the vertebral artery.

Nerve Supply.—The recti and obliqui are supplied by the posterior divisions of the first and second cervical nerves.

Sixth Layer.

Dissection.—The semi-spinales muscles must be removed to obtain a good view of the multifidus spinæ, which lies beneath them, and fills up the concavity between the spinous and transverse processes, the whole length of the vertebral column.

The **MULTIFIDUS SPINÆ**, consisting of about twenty-two small muscular fasciculi, extends along the vertebral groove from the sacrum to the axis. The muscle commences by tendinous fibres on the dorsum of the sacrum, proceeding from the lateral tubercles of the sacrum and even from the lateral cornu of the coccyx, and passing obliquely upwards and inwards to the spinous tubercles. The fasciculi *arise* inferiorly from the sacrum, ilium, and tendon of the erector spinæ; in the lumbar region from the articular and mammillary processes of the vertebræ; in the dorsal region from the transverse processes; and in the cervical region from the articular processes of the four inferior vertebræ. They are *inserted* into the spinous processes and laminæ of all the vertebræ from the sacrum to the axis. Of the twenty-two fasciculi, six are lumbar, twelve dorsal, and four cervical. Each fasciculus, separate below, spreads out as it ascends, and passing over the next vertebra, is inserted into the four or five immediately above it. The muscle is thick inferiorly; and the uppermost fasciculus larger than those immediately below it.

Relations.—By its *superficial surface* with the longissimus dorsi, semi-spinalis dorsi, and semi-spinalis colli. By its *deep surface* with the laminæ and spinous processes of the vertebral column, and in the cervical region with the ligamentum nuchæ.

The **ROTATORES SPINÆ** are situated in the dorsal region beneath the multifidus spinæ; they are eleven in number, and *arise* from the upper and back part of the transverse processes, and are *inserted* into the laminæ and roots of the spinous processes.

The **INTERSPINALES** are small muscular slips arranged in pairs and situated between the spinous processes of the vertebræ. In the *cervical region* there are six pairs of these muscles, the first being placed between the axis and third vertebra, the sixth between the last cervical and first dorsal; they are attached to the apices of the spinous processes, and are separated by the interspinous ligaments. In the *dorsal region*, rudiments of these muscles are occasionally met with between the upper and lower vertebræ, but are absent in the rest. In the *lumbar region* there are six pairs of interspinales, the first pair occupying the interspinous space between the last dorsal and first lumbar vertebræ, the last, the space between the fifth lumbar and sacrum. They are thin, broad, and imperfectly developed. Rudimentary interspinales are occasionally met with between the sacrum and coccyx; these are the analogues of the caudal muscles of brutes; in man they are named collectively the *extensor coccygis* (sacro-coccygeus posticus).

The **INTER-TRANSVERSALES** are small quadrilateral

muscles situated between the transverse processes of the vertebræ. In the *cervical region* they are arranged in pairs corresponding with the double conformation of the transverse processes, the vertebral artery and anterior division of a cervical nerve lying between them. The rectus anticus minor and rectus lateralis represent the inter-transversales between the atlas and cranium. In the *dorsal region* the anterior inter-transversales are represented by the intercostal muscles, while the posterior are mere tendinous bands, muscular only between the first and last vertebræ. In the *lumbar region*, the anterior inter-transversales are thin, and occupy only part of the space between the transverse processes. Analogues of posterior inter-transversales exist in the form of small muscular fasciculi extended between the mammillary processes of the lumbar vertebræ.

The **LEVATORES COSTARUM** are divided into long and short. The *short* (breves), twelve in number at each side, *arise* from the apex and lower border of the transverse process of the last cervical and eleven upper dorsal vertebræ; and pass downwards and outwards, radiating in their descent, to be *inserted* into the upper border of all the ribs, between the tuberosity and angle. The uppermost muscle is the smallest, and their breadth increases from above downwards.

The *long muscles*, four in number at each side, *arise* from the transverse processes of the dorsal vertebræ, the seventh to the tenth, and are *inserted* into the four lower ribs; each muscle passing over a rib in its descent, and being attached to the rib below as far as its angle. The long muscles lie superficially to the short ones and increase in size from above downwards.

Relations.—By their *superficial surface* with the sacro-lumbalis, longissimus dorsi, and transversalis cervicis. By their *deep surface* with the ribs and intercostal spaces; the short muscles close the intercostal spaces, and are united by their external border with the external intercostals.

Nerve Supply.—The multifidus spinæ, interspinales, inter-transversales, and levatores costarum are supplied by branches from the posterior divisions of the spinal nerves, from the atlas to the sacrum.

With regard to the origin and insertion of the muscles of the back, the student should be informed that no exact regularity attends their attachments. At the best, a knowledge of their precise connections, even were it possible to retain it, would be but a barren information, if not absolutely injurious, as tending to exclude more valuable learning. We have therefore arranged a plan, by which they may be more easily recollected, placing them in a tabular form (pp. 278, 279), that the student may see at a glance the origin and insertion of each, and compare the natural grouping and similarity of attachment of the various layers. In this manner their actions also will be better comprehended, and learned with greater facility.

In examining the table, the student will observe the constant

recurrence of the number *four* in the origin and insertion of the muscles. Sometimes the *four* occurs at the top or bottom of a region of the spine, and frequently includes part of two regions, taking two from each, as in the case of the serrati. Again, he will perceive that the muscles of the upper half of the table take their origin from spinous processes, and pass outwards to transverse, whereas the lower half arise mostly from transverse processes. To the student we commit these reflections, and leave it to the peculiar tenor of his own mind to make such arrangements as will be best retained in his memory.

Actions.—The upper fibres of the trapezius draw the shoulder upwards and backwards; the middle fibres, directly backwards; the lower, downwards and backwards. The lower fibres also produce rotation of the scapula on the chest, tilting the lower angle of that bone forwards and upwards, and carrying the upper angle slightly downwards and inwards; in this way the glenoid cavity is directed obliquely upwards and outwards, and the trapezius thus performs an important part in the elevation of the arm above the shoulder. If the shoulder be fixed, the upper fibres will flex the spine towards the corresponding side. The latissimus dorsi is a muscle of the arm, drawing it backwards and downwards, and at the same time rotating it inwards; if the arm be fixed, the latissimus dorsi will draw the spine to that side, and, raising the lower ribs, be an inspiratory muscle; and if both arms be fixed, the two muscles will draw the whole trunk forwards, as in climbing or walking on crutches. By passing over the inferior angle of the scapula it binds that bone to the thoracic wall, and by being folded round the axillary border it limits the outward projection of the same angle when the arm is raised. The levator anguli scapulæ lifts the upper angle of the scapula, and with it the entire shoulder; the rhomboidei carry the scapula and shoulder upwards and backwards, and approximate the inferior angle of the scapula to the spine.

The serrati are respiratory muscles acting in opposition to each other, the *serratus posticus superior* drawing the ribs upwards, and thereby expanding the chest; the *inferior* drawing the lower ribs downwards, and diminishing the cavity of the chest. The former is an inspiratory, the latter an expiratory muscle. The splenii muscles of one side draw the vertebral column backwards and to one side, and rotate the head towards the corresponding shoulder. The muscles of opposite sides acting together, draw the head directly backwards. They are direct antagonists of the sterno-mastoid muscles.

The *sacro-lumbalis* with its *accessory muscle*, the *longissimus dorsi* and *spinalis dorsi*, are known by the general term of *erector spinæ*, which sufficiently expresses their action. They keep the spine supported in the vertical position by their broad origin from below, and by their insertion, by distinct tendons, into the ribs and spinous processes. Being made up of a number of distinct fasciculi, which act alternately, the spine is kept erect without fatigue, even when

the muscles have to counterbalance a corpulent abdomen. The continuations upwards of these muscles into the neck preserve the steadiness and uprightness of that region. When the muscles of one side act alone, the neck is rotated on its axis. The *complexus*, being attached to the occipital bone, draws the head backwards, and counteracts the muscles of the anterior part of the neck. It assists also in the rotation of the head.

The *semi-spinalis* and *multifidus spinæ* muscles act directly on the vertebræ, and contribute to the general action of supporting the vertebral column erect.

The four little muscles situated between the occiput and the first two vertebræ, effect the various movements between these bones; the *recti* producing the antero-posterior actions, the *obliqui* the rotatory motions of the atlas on the axis.

The actions of the remaining muscles of the spine, the *rotatores spinæ*, *inter-spinales*, and *inter-transversales*, are expressed in their names. They approximate their attachments, and assist the more powerful muscles in preserving the erect position of the body.

The *levatores costarum* raise the posterior parts of the ribs, and are probably of service in preserving the articulation of the ribs from displacement, as well as in raising them in inspiration.

ORIGIN.

Layers.	Spinous Processes.	Transverse Processes.	Ribs.	Additional.
1st Layer.				
Trapezius	last cervical, 12 dorsal	. . .	. .	occipital bone and ligamentum nuchæ
Latissimus dorsi	4 or 6 lower dorsal, 5 lumbar	. . .	4 lower	sacrum and ilium .
2d Layer.				
Levator anguli scapulæ	. . .	4 upper cervical posterior tubercles .	. .	. . . .
Rhomboideus minor	lig. nuchæ and last cervical	. . .	. .	. . . .
Rhomboideus major	4 upper dorsal	. . .	. .	. . . .
3d Layer.				
Serratus posticus superior	lig. nuchæ, last cervical, 2 upper dorsal	. . .	. .	. . . .
Serratus posticus inferior	2 lower dorsal, 2 upper lumbar	. . .	. .	. . . .
Splenius capitis Splenius colli	lig. nuchæ, last cervical, 6 upper dorsal	. . .	. .	. . . .
4th Layer.				
Sacro-lumbalis	. . .	. . .	. .	ilium . . .
Accessorius ad sacro-lumbalem	. . .	. . .	angles, 6 lower	. . . .
Longissimus dorsi	. . .	. . .	. .	sacrum and lumbar vertebræ .
Spinalis dorsi	2 lower dorsal, 2 upper lumbar	. . .	. .	. . . .
Cervicalis ascendens	. . .	. . .	angles, 3d, 4th, 5th, 6th	. . . .
Tranversalis cervicis	. . .	5 or 6 upper dorsal, .	. .	. . . .
Trachelo-mastoid	. . .	3 upper dorsal, 1 lower cervical	. .	articular processes 4th, 5th, 6th cerv.
Complexus	. . .	3 upper dorsal, 1 lower cervical	. .	articular processes 4th, 5th, 6th cerv.
Biventer cervicis	. . .	dorsal 4th to 7th	. .	. . . .
5th Layer.				
Semi-spinalis dorsi	. . .	6th to 10th dorsal	. .	. . . .
Semi-spinalis colli	. . .	5 or 6 upper dorsal .	. .	. . . .
Rectus posticus major	axis . .	. . .	. .	. . . .
Rectus posticus minor	atlas . .	. . .	. .	. . . .
Rectus lateralis	. . .	atlas . .	. .	. . . .
Obliquus inferior	axis . .	. . .	. .	. . . .
Obliquus superior	. . .	atlas . .	. .	. . . .
6th Layer.				
Multifidus spinæ	. . .	from sacrum to 4th cervical	. .	sacrum, ilium, tendon of erector spinæ, articular proc.
Rotatores spinæ	. . .	12 dorsal .	. .	. . . .
Inter-spinales	cervical & lumbar	. . .	. .	. . . .
Inter-transversales	. . .	cervical & lumbar	. .	. . . .
Levatores costarum	. . .	last cervical and 11 upper dorsal	. .	. . . .

INSERTION.			
Spinous Processes.	Transverse Processes.	Ribs.	Additional.
			clavicle, acromion, and spine of scapula.
			bicipital groove of humerus.
			superior angle and base of scapula.
			base of scapula.
			base of scapula.
		2d, 3d, 4th, and 5th.	
		4 lower.	
	3 upper cervical		occipital and temporal bone, and mastoid process.
		angles of 6 lower.	
	last cervical	angles of 6 upper.	
	all the lumbar and dorsal	11 lower, between tubercles and angles.	
dorsal, 2nd to 6th or 8th.			
	3d, 4th, 5th, 6th cervical.		
	2d to 6th cervical.		
			mastoid process.
			occipital bone between the curved lines.
			occipital bone, superior curved line.
4 upper dorsal, 2 lower cervical.			
2d to 5th cervical.			
			occipital bone.
			occipital bone.
			occipital bone.
	atlas.		
			occipital bone.
all except atlas			all the laminæ, except atlas.
			12 dorsal laminæ.
cervical and lumbar.			
	cervical & lumbar		
		all between tubercles and angles.	

MUSCLES AND FASCIÆ OF THE THORAX.

The principal muscles situated on the front and sides of the thorax belong in their actions to the upper extremity, with which they will be described. They are the pectoralis major and minor, subclavius and serratus magnus. The true thoracic muscles, which appertain exclusively to the actions of the ribs, are the—

External intercostals,	Subcostals,
Internal intercostals,	Triangularis sterni.

The intercostal muscles are two planes of muscular and tendinous fibres directed obliquely between adjacent ribs and closing the intercostal spaces. They are seen partially on the reflection of the pectoral muscles, or on the inner surface of the chest. The triangularis sterni is within the chest, and requires the removal of the anterior part of the thorax to bring it into view.

FASCIÆ.—A thin layer of fascia covers the external surface of the external intercostal, and the inner surface of the internal muscle and a still finer layer is interposed between them. The surface layers become thicker in front, where the external intercostal is deficient, and behind, where the internal intercostal is wanting.

The **EXTERNAL INTERCOSTALS**, eleven on each side, commence posteriorly at the tubercles of the ribs, and advance forwards to the costal cartilages, where they terminate in a thin aponeurosis which is continued onwards to the sternum. Their fibres are directed obliquely downwards and forwards, pursuing the same line with those of the external oblique muscle of the abdomen. They are thicker than the internal intercostals, and more tendinous in structure.

The **INTERNAL INTERCOSTALS**, also eleven on each side, commence anteriorly at the sternum, and extend backwards as far as the angle of the ribs, whence they are prolonged to the vertebral column by a thin aponeurosis. Their fibres are directed obliquely downwards and backwards, corresponding with those of the internal oblique muscle of the abdomen, and crossing those of the external intercostals.

In structure the intercostal muscles consist of an admixture of muscular and tendinous fibres. They *arise* from the two lips of the lower border of the rib, the external from the outer lip, the internal from the inner; and are *inserted* into the upper border of the rib below, encroaching somewhat on its surfaces.

Nerve Supply.—The intercostal nerves.

The **SUBCOSTALS** are nine or ten small muscles situated within the thorax at its posterior part, and lying upon the ribs. They increase in size from above downwards, and the direction of their fibres corresponds with that of the intercostales interni. Each muscle *arises* from the front of a rib, and is *inserted* into the front of the rib but one below; the first subcostal is often absent.

Relations.—The external intercostals, by their *external surface*, with the muscles which immediately invest the chest, viz., pectoralis major and minor, serratus magnus, serratus posticus superior and inferior, scalenus posticus, sacro-lumbalis and longissimus dorsi with their continuations, cervicalis ascendens and transversalis cervicis, levatores costarum, and obliquus externus abdominis. By their *internal surface* with the internal intercostals, intercostal vessels and nerves, and posteriorly with the pleura, a thin layer of fascia being interposed. The internal intercostals, by their *external surface* with the external intercostals, and intercostal vessels and nerves; by their *internal surface* with the pleura costalis, triangularis sterni, subcostals, and diaphragm.

The **TRIANGULARIS STERNI**, situated upon the inner wall of the front of the chest, *arises* by a thin aponeurosis from the side of the sternum, ensiform cartilage, and sternal extremities of the costal cartilages from the third to the sixth or seventh; it is *inserted* by fleshy digitations into the second, third, fourth, and fifth costal cartilages and corresponding ribs.

Relations.—By its *external surface* with the sternum, ensiform cartilage, costal cartilages, internal intercostal muscles, and internal mammary vessels. By its *internal surface* with the pleura costalis, areolar tissue of the anterior mediastinum, and diaphragm. The lower fibres of the triangularis sterni are continuous with those of the transversalis abdominis.

Nerve Supply.—The intercostal nerves.

Actions of the Respiratory Muscles.—Respiration is produced by the alternate enlargement and diminution of the capacity of the thorax; the former resulting in the influx of air, or *inspiration*, and the latter in an expulsion of air, or *expiration*. The enlargement of the thoracic cavity takes in its three diameters, the vertical, transverse, and antero-posterior; the vertical measurement being increased by the descent of the diaphragm which forms the floor of the cavity; the transverse diameter by the elevation and rotation of the ribs, and the antero-posterior by the raising of the ribs and forward projection of the sternum. *Ordinary tranquil inspiration* is performed by the descent of the diaphragm and the elevation of the ribs and sternum by means of the intercostal muscles; when the act is more forcibly performed these are aided by the levatores costarum, scalene muscles, and serratus posticus superior. In *full inspiration* the scapula is fixed by means of the muscles which connect it with the vertebral column; the powerful muscles which pass from the shoulder to the ribs are then brought into play, and by their action elevate the ribs; these are the pectoralis major and minor, serratus magnus, and latissimus dorsi. Much difference of opinion prevails as to the action of the external and internal intercostals, many anatomists adhering to the theory taught by Hamberger that the external are inspiratory, and the internal expiratory muscles; while others accept the view so forcibly expounded by Hutchinson that the whole of the external and the part of the internal lying between the costal cartilages act in

inspiration, and the rest of the internal intercostals in expiration. But on the whole the weight of evidence seems chiefly to support the theory that both muscles act in common as muscles of inspiration, by raising the ribs, and so increasing the capacity of the thorax. *Ordinary tranquil expiration* is not a muscular act but an elastic and mechanical recoil, due to the elasticity of the lung-substance and the recoil of the chest wall after the muscles of inspiration have ceased to act. In *forced expiration* all the muscles which depress the ribs are brought into action, more especially those forming the abdominal wall (obliqui, transversalis, and recti), and the triangularis sterni and sacro-lumbalis. Lastly, it should be noted that certain muscles usually classed with those of expiration, from their being attached to the lower ribs, may in consequence of that attachment assist in inspiration, by giving a point of fixation and support for the action of the diaphragm; such are the serratus posticus inferior and quadratus lumborum.

MUSCLES AND FASCIÆ OF THE ABDOMEN.

The muscles of the abdominal region are the—

Obliquus externus (descendens),	Rectus,
Obliquus internus (ascendens),	Pyramidalis,
Cremaster,	Quadratus lumborum,
Transversalis,	Psoas parvus,

Diaphragm.

Dissection.—The dissection of the abdominal muscles is to be commenced by making three incisions:—The first, *vertical*, in the middle line, from over the lower part of the sternum to the pubes; the second, *transverse*, from the top of the first incision across the chest, as far back as the knife can be carried; the third, *oblique*, from the umbilicus, downwards and outwards, to the anterior superior spine of the ilium. The three flaps included by these incisions should then be dissected back in the direction of the fibres of the external oblique muscle, beginning at the angle of each. The integument and superficial fascia should be dissected off separately, so as to enable the student to examine the relation of the vessels to the parts connected with hernia.

Fasciæ.—The *superficial fascia* of the lower part of the abdomen deserves special attention in consequence of its relation to hernia and other surgical affections. It consists of two layers between which the superficial vessels are placed. They are the superficial epigastric, circumflex iliac, and external pudic arteries and veins, and the cutaneous lymphatics. The superficial or fatty layer is continuous with that of the abdomen above and thigh below, and is in contact with the skin. Its thickness depends on the general fatness of the subject, sometimes being little more than a membranous web, sometimes of considerable thickness. Along the groin the inguinal

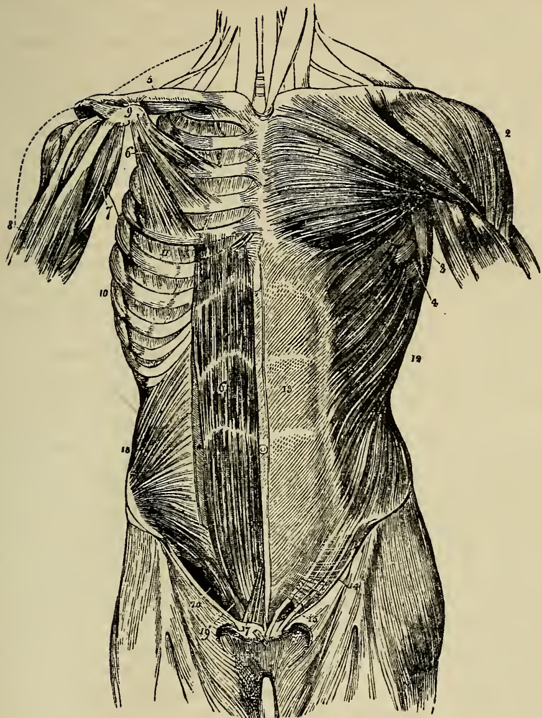
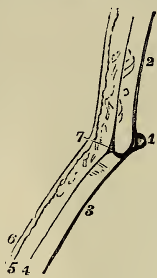


FIG. 193.—Muscles of the anterior aspect of the trunk; on the left side the superficial layer is seen, on the right the deeper layer. 1. Pectoralis major. 2. Deltoid; the interval between these muscles lodges the cephalic vein. 3. Anterior border of the latissimus dorsi. 4. Serratus magnus. 5. Subclavius, right side. 6. Pectoralis minor. 7. Coraco-brachialis. 8. Upper part of the biceps, showing its two heads. 9. Coracoid process of the scapula. 10. Serratus magnus, right side. 11. External intercostal muscle of the fifth intercostal space. 12. External oblique. 13. Its aponeurosis; the median line to the right of this number is the linea alba; the curved line to its left, the linea semilunaris; the transverse lines above and below the figure, the lineæ transversæ. 14. Poupart's ligament. 15. External abdominal ring; the margin above the ring is the superior or internal pillar; the margin below the ring, the inferior or external pillar; the curved intercolumnar fibres are seen proceeding upwards from Poupart's ligament to strengthen the ring. The numbers 14 and 15 are placed on the fascia lata of the thigh; the opening to the inner side of 15 is the saphenous opening. 16. Rectus muscle of the right side brought into view by the removal of the anterior segment of its sheath; * posterior segment of its sheath with the divided edge of the anterior segment. 17. Pyramidalis muscle. 18. Internal oblique. 19. Conjoined tendon of the internal oblique and transversalis descending behind Poupart's ligament to the pectineal line. 20. The arch formed between the lower curved border of the internal oblique muscle and Poupart's ligament; it is beneath this arch that the spermatic cord and oblique inguinal hernia pass.

lymphatic glands lie among the fatty substance. The deep or membranous layer lies on the abdominal aponeurosis, a thin layer of connective tissue being interposed. It is continued upwards over the abdomen, being closely adherent to the *linea alba*. From the lower part of this attachment a triangular piece is prolonged to the dorsum of the penis, and is called the suspensory ligament of the penis. At the groin this deep layer is attached to the *fascia lata* of the thigh by a piece which passes down from its under surface along the line of Poupart's ligament, but about half an inch further down the thigh. This process is called *Scarpa's fascia*. It is often described as being attached to Poupart's ligament, but really it is connected to the fascia lata, which itself is continued into the ligament. At the inner part of the groin the deep layer of superficial fascia is continued over the spermatic cord into the scrotum, where an accession of red involuntary muscular fibres takes place, and this, which forms the contractile tunic of the scrotum, is called the *dartos*. From the posterior part of the scrotum this superficial fascia is continued back into the perineum, where its deep or membranous layer ends by becoming attached to the triangular ligament at the posterior border of the *transversalis perinei*, and on each side to the ramus of the pubis. From this description it follows that if air or fluid be forced under the deep layer, it will travel through the connective tissue all over the abdomen, and could reach the scrotum and perineum, but could not pass down the thigh, being prevented by the connection of the fascia with the rami of the pubes, and the interposition of Scarpa's fascia in the groin; it would, moreover, be prevented from infiltrating the back part of the perineum by the deep layer of the superficial fascia being united to the deep perineal fascia along the posterior edge of the transverse perineal muscle.

Fig. 194.—Section showing the fasciæ at the groin. 1. Section of Poupart's ligament. 2. Aponeurosis of external oblique. 3. Fascia lata. 4. Membranous layer. 5. Superficial layer. 6. Skin. 7. Scarpa's fascia.



Linea Alba, &c.—When the external oblique muscle is dissected on both sides, a white tendinous line will be seen along the middle of the abdomen, extending from the ensiform cartilage to the pubes; this is the *linea alba*. A little external to it, on each side, two curved lines will be observed extending from the eighth rib to the spine of the pubes, and bounding the recti muscles; these are the *lineæ semilunares*. Some transverse lines, *lineæ transversæ*, three in number, connect the lineæ semilunares with the linea alba at and above the umbilicus.

The **EXTERNAL OBLIQUE MUSCLE** (*obliquus externus abdominis, descendens*) is the external flat muscle of the abdomen. Its name is derived from the obliquity of its direction, and the descending course of its fibres. It *arises* by fleshy digitations from

the external surface of the eight inferior ribs; the five upper digitations being received between corresponding processes of the serratus magnus, the three lower, of the latissimus dorsi. The fleshy fasciculi proceeding from this extensive origin terminate on the front of the abdomen in a broad aponeurosis, and posteriorly are *inserted* into the outer lip of the crest of the ilium for two-thirds its length, and into the anterior superior spinous process. The aponeurosis is united, in front, by its under surface, with that of the obliquus internus, forming the anterior wall of the sheath of the rectus, and is *inserted* into the linea alba, front of the pubes, spine of the pubes, and pectineal line.

The lower border of the aponeurosis, which is stretched between the anterior superior spinous process of the ilium and the spine of the pubes, is round from being folded inwards, and forms *Poupart's ligament;* the insertion into the pectineal line is *Gimbernat's ligament.*

Just above the crest of the pubes is the *external abdominal ring*, a triangular opening formed by the separation of the fibres of the aponeurosis of the external oblique. It is oblique in direction, and corresponds with the course of the fibres of the aponeurosis. It is bounded below by the crest of the pubes; on either side by the borders of the aponeurosis, which are termed *pillars;* and above by some curved fibres (*intercolumnar*) which originate from Poupart's ligament, and cross the upper angle of the ring, to give it strength. The *external pillar*, which is at the same time *inferior* from the obliquity of the opening, is inserted into the spine of the pubes; the *internal* or *superior pillar* forms an interlacement with its fellow of the opposite side over the front of the symphysis pubis. The inner fibres of the outer pillar pass behind the spermatic cord and internal pillar of the ring, and expanding into a thin triangular sheet, interlace with the corresponding fibres of the opposite side on the back part of the crest and symphysis pubis; they receive the name of *triangular fascia.* The external abdominal ring gives passage to the spermatic cord in the male, and the round ligament in the female: they are both invested in their passage through it by a prolongation of the fascia of the external oblique muscle, the *intercolumnar fascia*, or *fascia spermatica.*

The pouch of inguinal hernia, in passing through this opening, receives the *intercolumnar fascia* as one of its coverings.

Relations.—By its *external surface* with the superficial fascia, integument, cutaneous vessels and nerves, particularly the superficial epigastric and superficial circumflexa ilii vessels, and latissimus dorsi, by which it is overlapped posteriorly. By its *internal surface* with the internal oblique, lower part of the eight inferior ribs and intercostal muscles, cremaster, spermatic cord in the male, and round ligament in the female. The upper border of the external oblique is continuous with the pectoralis major.

Nerve Supply.—Anterior branches of the lower intercostals.

Dissection.—The external oblique is now to be removed by

making an incision from the anterior superior spine of the ilium towards the umbilicus as far as the aponeurosis can be separated from the subjacent muscle. From this latter point an incision is to be made to the crest of the pubis, and the aponeurosis included in these incisions to be turned down to Poupart's ligament. The remainder of the muscle may be removed by carrying a perpendicular incision from the end of the first up to the chest, and dissecting off the aponeurosis and muscle.

The **INTERNAL OBLIQUE MUSCLE** (*obliquus internus abdominis, ascendens*) is the middle flat muscle of the abdomen. It *arises* from the outer half of Poupart's ligament, from the middle of the crest of the ilium for two-thirds its length, and from the fascia lumborum. Its fibres diverge from their origin, those from Poupart's ligament curving downwards, those from the anterior part of the crest of the ilium passing transversely, and the rest ascending obliquely. The muscle is *inserted* into the pectineal line and crest of the pubes, linea alba, and lower border of the four inferior ribs. At its origin from the fascia lumborum it becomes the bond of union between the aponeurosis of the transversalis and that of the latissimus dorsi.

Along the upper three-fourths of the linea semilunaris, the aponeurosis of the internal oblique separates into two lamellæ, which pass one in front, the other behind the rectus muscle to the linea alba, where they are inserted ; along the lower fourth, the aponeurosis does not divide, but passes in front of the rectus. The two layers, which thus enclose the rectus for its upper three-fourths, consequently form for it a sheath, which is absent at its posterior inferior part.

The lowest fibres of the internal oblique are inserted into the pectineal line of the pubes in common with those of the transversalis muscle. Hence the tendon of this insertion is called the *conjoined tendon of the internal oblique and transversalis.* This tendon is situated directly behind the external abdominal ring, and serves to strengthen what would otherwise be a weak point in the abdomen. Sometimes the tendon is insufficient to resist the internal pressure and is forced through the external ring ; it then forms the distinctive covering of *direct inguinal hernia.*

The spermatic cord passes beneath the arched border of the internal oblique muscle, between it and Poupart's ligament. The interval between this lower border and Poupart's ligament is therefore called the spermatic or inguinal canal. During its passage some fibres are given off from the lower border of the muscle, which accompany the cord downwards to the testicle, and form loops around it ; this is the cremaster muscle. In the descent of oblique inguinal hernia, which travels the same course as the spermatic cord, the cremaster muscle forms one of its coverings.

The **CREMASTER**, considered as a distinct muscle, *arises* from the middle of Poupart's ligament, and forms a series of loops upon the spermatic cord. A few of its fibres are inserted into the tunica vaginalis, the rest (crus internum) ascends along the inner side of

the cord, to be *inserted*, with the conjoined tendon, into the pectineal line of the os pubis. Where the muscle spreads out over the tunica vaginalis and spermatic cord it receives the name of *cremasteric fascia.*

Relations.—The internal oblique is in relation by its *external surface* with the external oblique, latissimus dorsi, spermatic cord, and external abdominal ring. By its *internal surface* with the transversalis muscle, fascia transversalis, internal abdominal ring, and spermatic cord. By its *lower* and arched *border* with the spermatic cord; forming the upper boundary of the spermatic canal.

The cremaster is in relation by its *external surface* with the aponeurosis of the external oblique and intercolumnar fascia; by its *internal surface* with the fascia propria of the spermatic cord.

Dissection.—The internal oblique muscle is to be removed by making an incision from the anterior superior spine of the ilium horizontally inwards to the edge of the rectus, and another at right angles to this near the margin of the latter muscle to the ribs; the muscle is then to be separated from its anterior connections and turned backwards. Some degree of care will be required in performing this dissection, from the difficulty of distinguishing between this muscle and the one beneath. A thin layer of cellular tissue is all that separates them for the greater part of their extent. Near the crest of the ilium the deep circumflexa ilii artery ascends between the two muscles, and forms a guide to their separation; but just above Poupart's ligament they are so closely united that separation is impossible.

Nerve Supply.—Ilio-inguinal and ilio-hypogastric of first lumbar, and anterior branches of lower intercostals.

The **TRANSVERSALIS** is the internal flat muscle of the abdomen, and is transverse in the direction of its fibres, as implied in its name. It *arises* from the outer third of Poupart's ligament, from the anterior two-thirds of the internal lip of the crest of the ilium; from the transverse processes of the lumbar vertebræ through the medium of the posterior aponeurosis, and from the inner surface of the six inferior costal cartilages. The superior fibres, proceeding from the cartilage of the seventh rib, are *inserted* into the ensiform cartilage; the inferior fibres, proceeding from Poupart's ligament, curve downwards to be *inserted* by means of a tendinous expansion common to it, and the internal oblique, the *conjoined tendon of the internal oblique and transversalis*, into the pectineal line of the pubes; while the fibres intermediate between these points terminate near the outer border of the rectus in an aponeurosis, which is continued onwards to the linea alba. The upper portion of the aponeurosis, closely united with the posterior lamella of the aponeurosis of the internal oblique, assists in forming the posterior wall of the sheath of the rectus, while the inferior portion, commencing at a point midway between the umbilicus and pubes, is continued with the undivided aponeurosis of the internal oblique in front of the rectus.

Lumbar Fascia.—The *posterior aponeurosis* of the transversalis divides into three lamellæ, anterior, middle, and posterior, which constitute the *fascia lumborum*. The *anterior* lamella, thin and membranous, is attached to the base of the transverse processes of

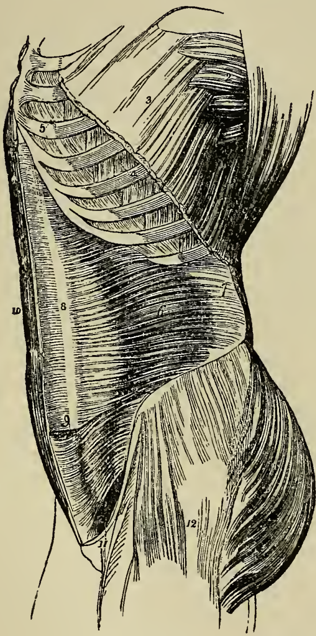


Fig. 195.—Lateral view of the trunk, showing its muscles, particularly the transversalis abdominis. 1. Costal origin of the latissimus dorsi. 2. Serratus magnus. 3. Upper part of the external oblique, divided in the direction best calculated to show the muscles beneath without interfering with its indigitations with the serratus magnus. 4. Two of the external intercostal muscles. 5. Two of the internal intercostals. 6. Transversalis. 7. Its posterior aponeurosis. 8. Its anterior aponeurosis, forming the posterior layer of the sheath of the rectus. 9. Lower part of the left rectus with the aponeurosis of the transversalis passing in front. 10. Right rectus muscle. 11. Arched opening left between the lower border of the transversalis muscle and Poupart's ligament, through which the spermatic cord and oblique inguinal hernia pass. 12. Tensor vaginæ femoris, gluteus medius and maximus invested by fascia lata.

the lumbar vertebræ; the *middle* lamella, of considerable thickness, to their apices; the *posterior* layer receives the attachment of the posterior aponeurosis of the internal oblique, and farther back, near the border of the erector spinæ, becomes united with the aponeurosis of the latissimus dorsi. Between the anterior and middle lamella is lodged the quadratus lumborum; and between the middle and posterior layer, the erector spinæ and multifidus spinæ, which are thus furnished with aponeurotic sheaths.

Relations.—By its *external surface* with the internal oblique, the internal surface of the six lower ribs, and internal intercostal muscles. By its *internal surface* with the transversalis fascia, which separates it from the peritoneum, with the psoas magnus, the lower part of the rectus, and pyramidalis. The spermatic cord and oblique inguinal hernia pass beneath the *lower border*, but have no direct relation with it. The *upper border* is continuous with the diaphragm and triangularis sterni.

Nerve Supply.—Anterior branches of lower intercostals.

Dissection.—To dissect the *rectus* muscle, its sheath should be opened by a vertical incision extending from over the cartilages of the lower ribs to the front of the os pubis. The sheath may then be dissected off and turned aside; this is easily done excepting at the lineæ transversæ, where a close adhesion exists between the muscle and the external wall of the sheath. The sheath contains the rectus and pyramidalis muscle.

The **RECTUS ABDOMINIS** *arises* by a double tendon from the front and crest of the os pubis, and is *inserted* by three broad digitations into the outer surfaces of the cartilages of the fifth, sixth, and seventh ribs. It is traversed by several tendinous intersections, called lineæ transversæ (inscriptiones tendineæ). One of these is situated at the umbilicus, one over the ensiform cartilage, and one midway between these points; when a fourth exists, it occurs below the umbilicus. The lineæ transversæ are homologues of the abdominal ribs of reptiles, and rarely extend completely through the muscle.

Relations.—By its *external surface* with the anterior lamella of the aponeurosis of the internal oblique, below with the aponeurosis of the transversalis, and with the pyramidalis. By its *internal surface* with the ensiform cartilage, cartilages of the ribs from the fifth to the ninth, posterior lamella of the internal oblique, peritoneum, and epigastric artery and veins.

Nerve Supply.—The ilio-hypogastric and anterior branches of intercostal nerves.

The **PYRAMIDALIS** *arises* from the crest of the os pubis in front of the rectus, and is *inserted* into the linea alba at about midway between the umbilicus and pubes. It is enclosed in the sheath with the rectus, and rests against the lower part of that muscle; it is sometimes absent.

Nerve Supply.—The ilio-hypogastric nerve.

The rectus may now be divided across the middle, and the two ends drawn aside for the purpose of examining the mode of construction of its sheath.

Sheath of the Rectus.—This is formed, *in front*, for the upper three-fourths of its extent, by the aponeurosis of the external oblique and anterior lamella of the internal oblique; *behind* by the posterior lamella of the internal oblique and aponeurosis of the transversalis. Midway between the umbilicus and the pubes, the posterior wall of the sheath terminates in a thin curved margin (*semilunar fold of Douglas*), the aponeurosis of the three muscles passing, below this point, altogether in front of the rectus.

Fascia Transversalis.—This is a thin fibrous membrane which lines the inner surface of the transversalis muscle and the other structures which form the abdominal wall where that muscle is absent. It is continuous behind with the iliac, and below with the pelvic fascia. It is strong and tough at the lower part of the abdomen, but at the upper, where it is continued on to the diaphragm, it is little more than loose areolar tissue. In the centre it lines the

back part of the sheath of the rectus, and where that is absent lines the rectus muscle and is attached to the crest of the pubis. At the sides it is attached to the inner lip of the crest of the ilium and along the whole length of Poupart's ligament, where it is connected to the fascia lata, and for the outer half of the ligament to the iliac fascia which joins it behind. The union of these three fasciæ takes place rather under than in Poupart's ligament, which could therefore be cut away, leaving them connected together as a firm fibrous cord, to which is given the name of the **crural arch.** At the inner half of Poupart's ligament it is prolonged into the thigh, forming the anterior part of the sheath of the femoral vessels, as the posterior part is formed of a similar prolongation of the iliac fascia.

The **internal abdominal ring** is an opening in this fascia situated about half-way between the anterior superior spine of the ilium and the symphysis of the pubis, and half an inch above Poupart's ligament. It is oval in form, the lower edge being strong, the upper thin and weak. Through this opening the spermatic cord in the male passes to the testicle, and the round ligament of the uterus in the female to its insertion over the pubis. From the edges of the ring a funnel-shaped tube of transversalis fascia is given off which surrounds the structures forming the spermatic cord. This is the **infundibuliform fascia**, sometimes called the **fascia propria** of the cord. The internal abdominal ring, therefore, is simply the funnel-shaped mouth of this tube, and it is situated immediately external to the deep epigastric artery round which the spermatic cord turns in its passage from the abdomen to the scrotum.

SURGICAL ANATOMY OF INGUINAL HERNIA.

Inguinal hernia is of two kinds, oblique and direct.

In **OBLIQUE INGUINAL HERNIA** the intestine escapes from the cavity of the abdomen into the *spermatic or inguinal canal*, through the *internal abdominal ring*, pressing before it a pouch of peritoneum which constitutes the *hernial sac*, and distending the infundibuliform process of the transversalis fascia. After emerging through the internal abdominal ring it passes *firstly* beneath the lower and arched border of the transversalis muscle ; *then* beneath the lower border of the internal oblique muscle ; and *finally* through the *external abdominal ring*, in the aponeurosis of the external oblique. From the transversalis muscle it receives no investment; while passing beneath the lower border of the internal oblique it obtains the cremaster muscle; and on escaping at the external abdominal ring, receives the intercolumnar or spermatic fascia. So that the coverings of an oblique inguinal hernia, after it has emerged through the external abdominal ring, are, from the surface to the intestine, the—

Integument,	Cremaster muscle,
Superficial fascia,	Transversalis, or infundibuliform fascia,
Intercolumnar fascia,	Peritoneal sac.

Inguinal Canal.—The spermatic or inguinal canal, which in the normal condition of the abdominal parietes serves for the passage of the spermatic cord in the male, and the round ligament with its vessels in the female, is about one inch and a half in length. It is bounded, *in front*, by the aponeurosis of the external oblique muscle

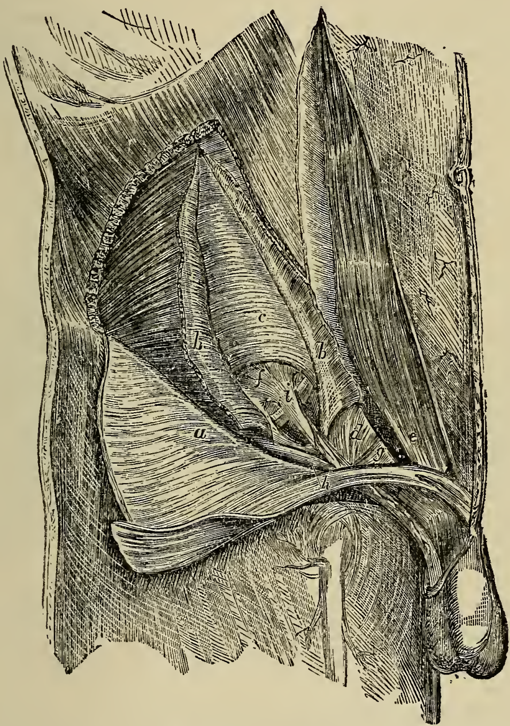


FIG. 196.—Dissection of the inguinal canal. *a*. External oblique (turned down). *b*, *b*. Internal oblique. *c*. Transversalis. *d*. Conjoined tendon. *e*. Rectus, with sheath opened. *f*. Fascia transversalis. *g*. Triangular fascia. *h*. Cremaster. *i*. Infundibular fascia.

and a few fibres of the internal oblique and cremaster; *behind*, by the transversalis fascia, the conjoined tendon of the internal oblique and transversalis, and triangular fascia; *above*, by the arched border of the internal oblique and transversalis; *below*, by the grooved border of Poupart's ligament; and at each extremity by one of the abdominal rings, the internal ring at the inner, the external ring at the

outer extremity. These relations may be more distinctly illustrated by the following plan :—

Above.
Lower border of internal oblique and transversalis.

In front.		*Behind.*
Aponeurosis of external oblique fibres of internal oblique and cremaster.	Inguinal canal.	Transversalis fascia. Conjoined tendon of internal oblique and transversalis. Triangular fascia.

Below.
Grooved border of Poupart's ligament.

There are three varieties of oblique inguinal hernia: common, congenital, and infantile.

FIG. 197.—Diagram of a common scrotal hernia, showing the relation of the sac to the tunica vaginalis testis.

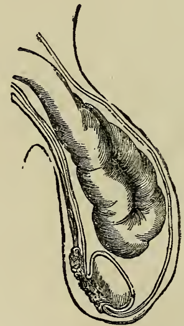


FIG. 198.—Diagram of a congenital hernia, the sac being continuous with the tunica vaginalis testis.

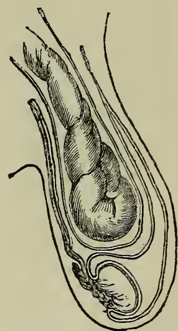


FIG. 199.—Diagram of an infantile hernia, showing the tunica vaginalis prolonged in front of the sac.

Common oblique hernia is that which has been described above.

Congenital hernia results from the non-closure of the pouch of peritoneum carried downwards into the scrotum by the testicle, during its descent in the fœtus. In consequence of this defect, the intestine at some period of life is forced into the peritoneal canal, and descends through it into the tunica vaginalis, where it lies in contact with the testicle; so that congenital hernia has *no proper sac*, but is contained within the tunica vaginalis. The other coverings are the same as those of common inguinal hernia.

Infantile or encysted hernia is that form of protrusion in which the pouch of peritoneum forming the tunica vaginalis is only par-

tially closed. The connection with the abdomen is completely closed at the inguinal canal, but the rest of the tube remains in its original state, and when a hernia makes its way into the scrotum it lies behind the enclosed tunica vaginalis. So that the surgeon, in operating upon this variety, requires to divide three layers of serous membrane; the first and second layer being those of the tunica vaginalis, the third the true sac of the hernia.

DIRECT INGUINAL HERNIA has received its name from passing *directly* through the external abdominal ring, and forcing before it the opposing parietes. This portion of the wall of the abdomen is strengthened by the conjoined tendon of the internal oblique and transversalis, which is pressed before the hernia, and forms one of its investments. Its coverings, therefore, are the—

Integument,	Conjoined tendon,
Superficial fascia,	Transversalis fascia,
Intercolumnar fascia,	Peritoneal sac.

Direct inguinal hernia differs from oblique, firstly, in never attaining the same bulk, in consequence of the resisting nature of the conjoined tendon of the internal oblique and tranversalis and transversalis fascia; secondly, in its direction having a tendency to protrude *from* the middle line rather than towards it. Thirdly, in making for itself a new passage through the abdominal parietes, instead of following a natural channel; and fourthly, in the relation of the neck of its sac to the epigastric artery; that vessel lying to the outer side of the opening of the sac of direct hernia, and to the inner side of that of oblique hernia.

All the forms of inguinal hernia are designated *scrotal*, when they have descended into the scrotum; the oblique inguinal is most frequently found in this situation, from its following the course of the spermatic cord.

MUSCLES OF THE POSTERIOR WALL OF THE ABDOMEN, AND DIAPHRAGM.

Dissection.—The next two muscles can be examined only when the viscera of the abdomen are removed. To see the quadratus lumborum, it is also necessary to divide and draw aside the psoas muscle and the anterior lamella of the posterior aponeurosis of the transversalis.

The **QUADRATUS LUMBORUM** is concealed from view by the anterior lamella of the posterior aponeurosis of the transversalis muscle, which is inserted into the bases of the transverse processes of the lumbar vertebræ. When this lamella is divided, the muscle will be seen to consist of two portions:—one, the *external*, *arising* from the ilio-lumbar ligament and outer lip of the crest of the ilium for two inches in extent, and *inserted* into the apices of the transverse processes of the four upper lumbar vertebræ

(sometimes also last dorsal) and last rib; the other, the *internal* and anterior portion, *arises* by tendinous slips from the transverse processes of the three or four lower lumbar vertebræ, and passes upwards to be *inserted* into the lower border of the last rib. If the muscle be cut across or removed, the middle lamella of the aponeurosis of the transversalis will be seen, attached to the apices of the transverse processes; the quadratus being enclosed between the two lamellæ as in a sheath.

Relations.—Enclosed in the sheath formed by the aponeurosis of the transversalis muscle, it is in relation, *in front*, with the kidney, colon, psoas magnus, and diaphragm. *Behind*, but also separated by its sheath, with the erector spinæ.

Nerve Supply.—Posterior branches of the lumbar nerves.

The **PSOAS PARVUS** is a small and infrequent muscle which *arises* from the last dorsal and first lumbar vertebra and from the intervertebral substance between them, and terminates in a long slender tendon which expands inferiorly and is *inserted* into the pectineal line and eminence. The tendon is continuous by its outer border with the iliac fascia.

Relations.—It rests on the psoas magnus, and is covered in by the peritoneum; superiorly it passes beneath the ligamentum arcuatum internum of the diaphragm.

Nerve Supply.—Branches of the lumbar plexus.

DIAPHRAGM.—To obtain a good view of this important inspiratory muscle, the peritoneum should be dissected from its under surface. It is a transverse muscular septum between the thorax and abdomen, and is composed of two portions, thoracic and lumbar, the former being named the greater, the latter the lesser muscle. The **thoracic portion** *arises* from the ensiform cartilage by a distinct slip and from the internal surface of the six inferior ribs, indigitating with the transversalis. The fibres converge to be *inserted* into the central tendon.

A triangular interval exists between the sternal and costal portion of the muscle at each side, closed by a few irregular muscular fibres and by the serous membranes of the cavity of the chest and abdomen. A protrusion of any portion of the contents of the abdomen through this opening constitutes *phrenic* or *diaphragmatic hernia.*

The **lumbar portion** consists of a right and left lateral half (*pillars, crura*); each of which is composed of *three* smaller pillars or crura, *internal*, *middle*, and *external.*

The **crura** *arise* from the front and lateral aspect of the bodies of the first, second, and third lumbar vertebræ, from the intervertebral substance between the first, second, third, and fourth, from the transverse process of the first, ligamentum arcuatum internum and externum, and last rib. The *left crus* is shorter than the right by the breadth of a vertebra, and does not advance so far forward on the front of the vertebral column. The crura are *inserted* into the whole length of the posterior border of the central tendon.

The origin of the crura takes place by a strong tendon, from which

and from the other points of attachment muscular fibres proceed. The *internal pillar* of the crus is its anterior fasciculus, which proceeds from the third lumbar vertebra; the *middle pillar*, smaller than the others, proceeds from the second vertebra; the *external pillar*, the largest of the three, from the first lumbar vertebra, ligamenta arcuata, and last rib. The internal pillars approach each other as they ascend, the arched interval between them being the aortic opening; their internal fibres, consisting of several fasciculi, cross each other in front of the aortic opening and form the lateral boundaries of another opening of elliptical shape (œsophageal), and are then lost in the central tendon. In the decussation between the

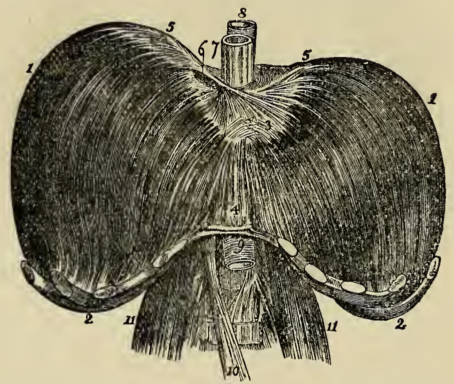


FIG. 200. — The diaphragm viewed from the front, showing its upper or thoracic surface. 1, 1. The lateral segments of the thoracic portion; arising from 2, 2. The cartilages of the ribs; and inserted into 3. The central tendon. The right segment is seen to be higher than the left. 4. The fasciculus which arises from the ensiform cartilage. 5, 5. Lateral leaflets of the central tendon. 6. Opening for the inferior vena cava. 7. The œsophagus. 8. The thoracic aorta. 9. The abdominal aorta. 10. The tendon of the right crus of the diaphragm: that of the left is seen immediately above on the lumbar vertebræ. 11, 11. The psoas muscles.

aortic and œsophageal opening the fibres of the right internal pillar are generally the most superficial. Between the lumbar and costal portion of the diaphragm at each side is a triangular interval like that between the costal and sternal portion, closed only by cellular tissue and the serous membranes of the two cavities.

The **ligamentum arcuatum internum** is a tendinous arch thrown across the upper part of the psoas muscle from the side of the body of the first lumbar vertebra to the apex of its transverse process, extending sometimes also to that of the second. Beneath this arch the psoas magnus emerges from the chest.

The **ligamentum arcuatum externum** is a tendinous band extended from the apex of the transverse process of the first lumbar vertebra to the lower border of the last rib. It forms an arch across the quadratus lumborum, and is continuous with the anterior wall of the sheath of that muscle derived from the posterior aponeurosis of the transversalis abdominis.

The **tendinous centre** of the diaphragm is shaped like a trefoil

leaf, of which the central leaflet points to the ensiform cartilage, and is the largest; the lateral leaflets, right and left, occupy the corresponding portions of the muscle; the right being the larger and rounded, the left smaller and lengthened in its form.

The **openings in the diaphragm** are three: one, *quadrilateral*, in the tendinous centre, at the union of the right and middle leaflets,

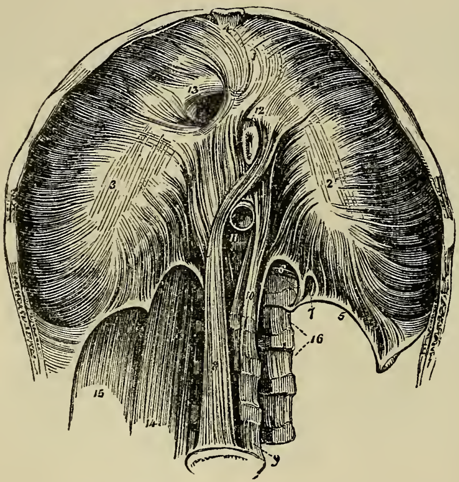


Fig. 201. — Under or abdominal side of the diaphragm. 1, 2, 3. The thoracic portion; figure 1 rests on the central leaflet of the tendinous centre; figure 2 on the left or smallest leaflet; figure 3 on the right leaflet. 4. Fasciculus from the ensiform cartilage; a small triangular space, closed only by the serous membranes of the abdomen and chest, is left on either side of the fasciculus. 5. Ligamentum arcuatum externum of the left side. 6. Ligamentum arcuatum internum. 7. A small arched opening occasionally found, through which the lesser splanchnic nerve passes. 8. Tendon of the right or larger crus; a muscular fasciculus from this tendon curves to the left side of the greater muscle between the œsophageal and aortic opening. 9. Fourth lumbar vertebra. 10. Tendon of the left or shorter crus. 11. Aortic opening occupied by the cylinder of the aorta. 12. Portion of the œsophagus issuing through the œsophageal opening; in this figure the œsophageal opening is tendinous at its anterior part, a state that is not uncommon. 13. Opening for the inferior vena cava, in the tendinous centre of the diaphragm. 14. Psoas magnus passing beneath the ligamentum arcuatum internum; it has been removed on the opposite side to show the arch more distinctly. 15. Quadratus lumborum passing beneath the ligamentum arcuatum externum; this muscle has also been removed on the left side. 16. Transverse processes of lumbar vertebræ, and intertransverse muscles.

for the passage of the *inferior vena cava* and a branch of the *phrenic nerve;* a muscular opening of an elliptical shape formed by the internal pillars of the crura, the *œsophageal*, for the transmission of the *œsophagus* and *pneumogastric nerves;* a third, the *aortic*, formed by a tendinous arch thrown from the tendon of one crus to that of the other, beneath which pass the *aorta*, *vena azygos major*, and *thoracic duct.* The great splanchnic nerve passes through the diaphragm between the internal and middle pillar of the crus; the lesser splanchnic nerve escapes between those fibres of the external pillar which proceed from the ligamentum arcuatum internum. The

sympathetic chain passes into the abdomen beneath the ligamentum arcuatum internum, and the vena azygos minor passes from the abdomen to the thorax through the left crus of the diaphragm.

Relations.—By its *superior surface* with the pleuræ, pericardium, heart, and lungs. By its *inferior surface* with the peritoneum; on the left with the stomach and spleen; on the right with the convexity of the liver; behind with the kidneys, supra-renal capsules, duodenum, and solar plexus. By its *circumference* with the ensiform cartilage, ribs, intercostal muscles, and vertebral column.

Nerve Supply.—The phrenic nerve, derived from the third, fourth, and fifth cervical.

Actions of the Muscles of the Abdominal Wall and the Diaphragm.—The external oblique muscle, acting singly, draws the thorax towards the pelvis, and twists the body to the opposite side. Both muscles, acting together, flex the thorax directly on the pelvis. The internal oblique of one side draws the chest downwards and outwards; both together bend it directly forwards. Either transversalis muscle, acting singly, will diminish the size of the abdomen on its own side, and both together will constrict the entire cylinder of the cavity. The recti muscles, assisted by the pyramidales, flex the thorax towards the pelvis, and, through the medium of the lineæ transversæ, are enabled to act when their sheath is curved inwards by the action of the transversales. The pyramidales are tensors of the linea alba. The abdominal are expiratory muscles, and chief agents in expulsion; by their action, the fœtus is expelled from the uterus, the urine from the bladder, fæces from the rectum, bile from the gall-bladder, ingesta from the stomach and bowels in vomiting, and mucus and irritating substances from the bronchial tubes, trachea, and nasal passages during coughing and sneezing. To produce these effects, they all act together. Their violent and continued action produces hernia, and, acting spasmodically, they may occasion rupture of the viscera. The quadratus lumborum draws the last rib downwards, and is an expiratory muscle; it also serves to bend the vertebral column to one or the other side. The psoas parvus is a tensor of the iliac fascia, and, taking its fixed origin from below, may assist in flexing the vertebral column forwards. The diaphragm is an inspiratory muscle, and the sole agent in tranquil inspiration. When in action, the muscle is drawn downwards, its plane being rendered oblique from the level of the ensiform cartilage, to that of the upper lumbar vertebra. During relaxation it is convex, and encroaches considerably on the cavity of the chest, particularly at the sides, where it corresponds with the lungs. It assists the abdominal muscles powerfully in expulsion, every act of that kind being preceded or accompanied by inspiration. Spasmodic action of the diaphragm produces hiccough and sobbing, and its rapid alternation of contraction and relaxation, combined with laryngeal and facial movements, laughing and crying.

MUSCLES AND FASCIÆ OF THE PERINEUM.

The muscles of the perineum are situated in the outlet of the pelvis, and consist of two groups, one of which belongs especially to the organs of generation and urethra, the other to the termination of the alimentary canal. To these may be added the muscles of the coccyx. The muscles of the perineal region in the male are the—

Accelerator urinæ,	Sphincter ani,
Erector penis,	Levator ani,
Transversus perinei,	Coccygeus.
Compressor urethræ,	

Dissection.—To dissect the perineum, the subject should be fixed in the position for lithotomy, that is, the hands should be bound to the soles of the feet, and the knees kept apart. An easier plan is the drawing of the feet upwards by means of a cord passed through a hook in the ceiling. Both of these means of preparation have for their object the full exposure of the perineum. And as this is a dissection which demands some degree of delicacy and nice manipulation, a strong light should be thrown upon the part. A large sound is to be introduced into the bladder, and a string, tied round the testicles, to be fixed to its handle. This will retain the sound in the bladder and put the perineum on the stretch. An incision is to be made from the point where the scrotum joins the perineum along the middle of the latter to the anterior edge of the anus, round each side of this, and from the posterior edge of it to the tip of the coccyx. This incision is to be supplemented by lateral ones carried from the anterior end of the first outwards on to the thigh and then backwards to a little beyond the level of the posterior margin of the anus, so as to include in its area the tuberosity and ramus of the ischium. The flaps are to be dissected back with great care, the integument alone being removed so as to expose the subcutaneous sphincter and the superficial fascia. After the fascia has been carefully dissected off and the perineal vessels and nerves turned aside, the muscles are brought into view.

Perineal Fasciæ.—The fasciæ of the perineum are the superficial and the deep.

The **superficial fascia** consists as in other situations of two layers, one lying next the skin and containing an abundance of fat, the other more condensed lying in contact with the muscles.

The **superficial layer**, or fatty layer, in the perineum is connected with the raphé at the middle line and with the external border of the sphincter ani, and is continuous, by its circumference, with the dartos of the scrotum, or cellular tissue of the labia majora, in front, with the superficial fascia of the thighs at each side, and with the superficial fascia covering the glutei maximi and with the coccyx behind. In the posterior part of the perineum it is loaded with granular fat and fills up the *ischio-rectal fossa.*

The **deep** or **membranous layer** of the superficial fascia, or fascia of Colles, lies in close contact with the muscles and superficial vessels of the perineum, packing them into their places. On each side it is attached to the ramus of the ischium and pubes, and this attachment is continued forwards and outwards on to the fascia lata of the thigh, where it becomes continuous with Scarpa's fascia. It is prolonged backwards as far as the transversalis perinei muscle, round the posterior border of which it turns to be united to the deep perineal fascia on which the muscle rests. At this point these two fasciæ are blended together, and are then continued backwards on the outer surface of the levator ani, on which they form a very thin membrane called the anal fascia, which is prolonged up into the pelvis to the division of the pelvic fascia. It is continued forwards to blend with the dartos. The attachment of the membranous layer to the deep perineal fascia explains why an extravasation of fluid under that membrane could not pass back into the posterior half of the perineum, but could find its way, as it often does, into the scrotum and up over the abdomen.

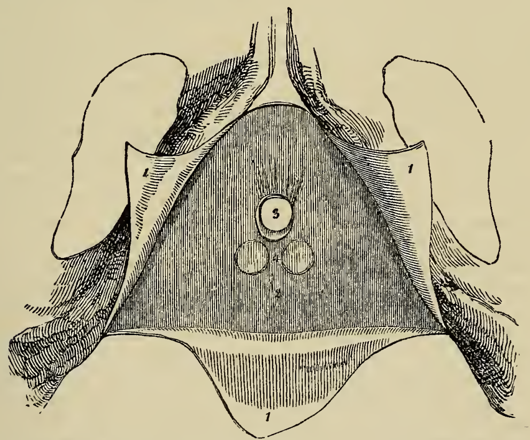


FIG. 202.—The pubic arch and perineal fasciæ. 1, 1, 1. The deep layer of the superficial perineal fascia divided by a Λ-shaped incision into three flaps; the lateral flaps are turned over the ramus of the pubes and ischium at each side, to which they are firmly attached; the posterior flap is continuous with the deep perineal fascia or triangular ligament. 2. The triangular ligament of the urethra. 3. Opening for the passage of the membranous portion of the urethra, previously to the entrance of the latter into the bulb. 4. Two projections of the triangular ligament corresponding with the position of Cowper's glands.

The **deep perineal fascia** or **triangular ligament** of the urethra is a strong aponeurotic sheet which is stretched across the inter-pubic arch. It is attached firmly to the sub-pubic ligament, and to the ramus of the pubes and ischium. At the posterior border of the

transversalis perinei muscle, it has attached to it the deep layer of the superficial fascia, and with it is prolonged back on the levator ani muscle, as the *anal* fascia. At an inch and a half from the symphysis pubis, in the middle line, it is connected to the central tendinous point of the perineum. The deep perineal fascia may therefore be described as a complete bag-like floor to the pelvis, continued in front to the sub-pubic ligament, behind, over the levator ani to the coccyx, on each side to the ramus of the pubes and ischium, and behind these to the white line of separation between the parietal or obturator and the visceral or internal layers of the pelvic fascia. But the part stretched across the arch of the pubes is that to which the name of **triangular ligament** is restricted. About an inch below the symphysis pubis it is pierced for the passage of the membranous portion of the urethra, which is contained between it and the pelvic fascia behind, to which is sometimes given the name of posterior layer of the triangular ligament. Immediately below the sub-pubic ligament the dorsal vein of the penis passes back through it to join the prostatic plexus, and on each side, a little in front of this, the pudic arteries pass through it to enter the corpora cavernosa penis. Immediately behind the deep perineal fascia in the anterior half of the perineum are situated the compressor urethræ muscle, the internal pudic arteries, the arteries of the bulb, and Cowper's glands, besides the membranous part of the urethra, all of which rest on that part of the pelvic fascia which is applied across the pubic arch, and to which, as has been stated, is sometimes given the name of the posterior layer of the triangular ligament. In the posterior section of the perineum, the deep perineal fascia under the name of the anal fascia covers the levator ani muscle. The sphincter ani being subcutaneous, surrounds the anus, only a little connective tissue being interposed between its fibres and the skin.

The **ACCELERATORES URINÆ** (bulbo-cavernosi) *arise* from a tendinous point in the centre of the perineum, and from the fibrous raphé of the two muscles. From this origin the fibres diverge like the barbs of a pen; the posterior to be *inserted* into the triangular ligature and ramus of the pubes; the middle, to encircle the corpus spongiosum and meet on its upper side; the anterior, to spread out on the corpus cavernosum at each side, and be inserted partly into its fibrous structure, and partly into the fascia penis. From the last insertion a fibrous slip is said to be continued over the dorsal vessels of the penis. The posterior and middle insertions of these muscles are best seen by carefully raising one muscle from the corpus spongiosum and tracing its fibres.

Relations.—By their *superficial surface* with the superficial perineal fascia, dartos, superficial vessels and nerves of the perineum, and, on each side, the erector penis. By their *deep surface* with the corpus spongiosum and bulb of the urethra.

The **ERECTOR PENIS** (ischio-cavernosus) *arises* from the tuberosity of the ischium and from the ramus of the pubes behind the extremity of the crus, and curves around the root of the penis;

PLATE 21.

THE MALE PERINEUM.

FIG. 1.—SUPERFICIAL DISSECTION SHOWING THE VESSELS AND NERVES.

FIG. 2.—DISSECTION SHOWING THE MUSCLES.

A. Urethra.
B. Accelerator urinæ.
C. Central point of perineum.
D. Erector penis.
E. Transversus perinei.
F. Anus.
G. Tuber ischii.

H. Coccyx.
I. Gluteus maximus.
K. Levator ani.
L. Triangular ligament.
1. Superficial perineal vessels and nerves.
2. Inferior hæmorrhoidal vessels and nerves.

PLATE 21.

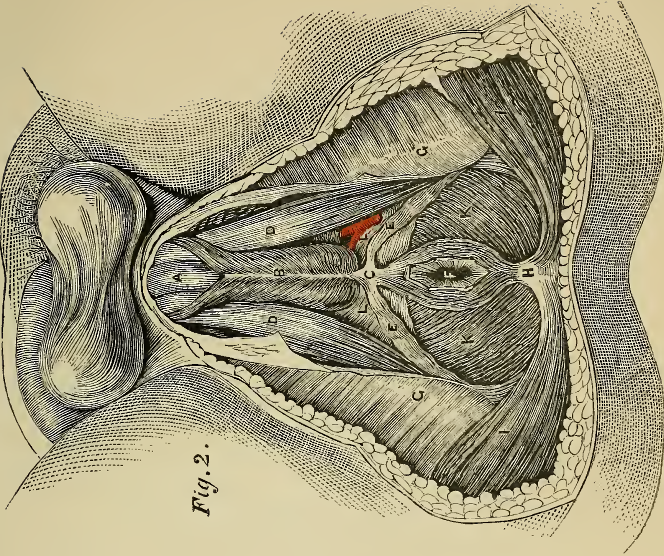


Fig. 2.

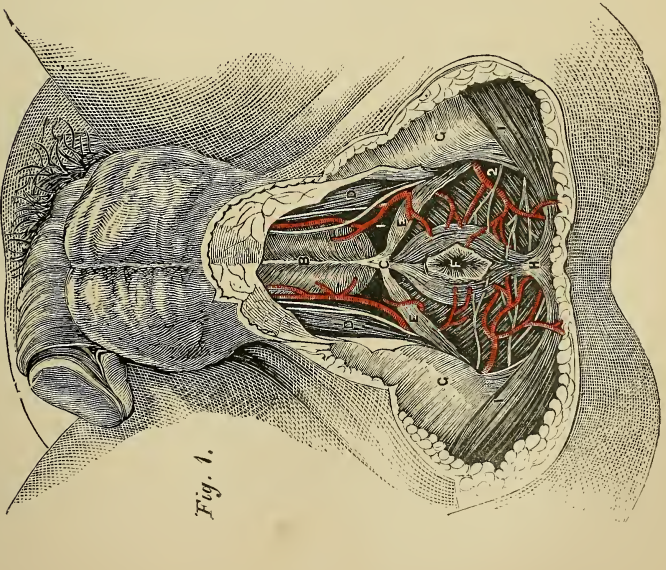


Fig. 1.

to be *inserted* into the upper surface of the corpus cavernosum, where it is continuous with a strong fascia which covers the dorsum of the organ, the *fascia penis.*

Relations.—By its *superficial surface* with the superficial perineal fascia, dartos, and superficial perineal vessels and nerves. By its *deep surface* with the corpus cavernosum penis.

Nerve Supply.—The perineal branch of the pudic nerve supplies the acceleratores urinæ and the erector penis.

The **TRANSVERSUS PERINEI** *arises* from the ramus of the ischium at each side, and is *inserted* into the central tendinous point of the perineum, where it is connected with the accelerator urinæ and sphincter ani. Occasionally the transversus perinei is of large size,

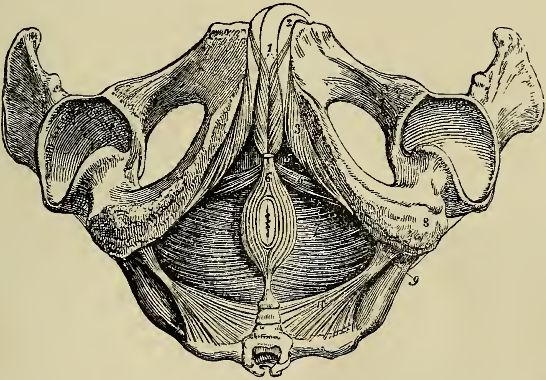


Fig. 203.—Muscles of the perineum. 1. Acceleratores urinæ; the figure rests on the corpus spongiosum penis. 2. Corpus cavernosum of one side. 3. Erector penis of one side. 4. Transversus perinei of one side. 5. Triangular space, through which the triangular ligament is seen. 6. Sphincter ani; its anterior extremity cut off. 7. Levator ani of the left side; the deep space between the tuberosity of the ischium (8) and the anus, is the ischio-rectal fossa; the same fossa is seen on the opposite side. 9. Spine of the ischium. 10. Left coccygeus muscle. The boundaries of the perineum are well exhibited in this engraving.

and spreads out as it approaches the middle line so as to become fan-shaped. The posterior fibres are continuous with those of the muscle of the opposite side; but the anterior are prolonged forwards upon the bulb and corpus spongiosum of the urethra, and are sometimes traceable as far as the middle of the penis, when they form a broad layer which usurps the place and office of the accelerator urinæ.

A *deep transverse perineal* muscle is often found behind the anterior layer of the triangular ligament; it *arises* from the ramus of the ischium, and meeting with its fellow of the opposite side behind the bulb of the urethra, is *inserted* into the back part of the central tendinous point. Its fibres conceal Cowper's gland.

Relations.—The superficial muscle is in relation by its *superficial surface* with the superficial perineal fascia, and superficial perineal

vessels and nerves. By its *deep surface* with the triangular ligament and internal pudic artery and veins. By its *posterior border* it is in relation with that portion of the superficial perineal fascia which passes upwards to become continuous with the triangular ligament.

Nerve Supply.—The perineal branch of the pudic nerve.

Dissection.—To dissect the *compressor urethræ*, the three preceding muscles should be removed, so as to render the glistening surface of the triangular ligament apparent. This ligament should then be carefully dissected away, and the corpus spongiosum penis divided through its middle, separated from the corpus cavernosum, and drawn forwards in order to put on the stretch the membranous portion of the urethra, with which the compressor muscles are connected. The compressor urethræ is, however, better seen in a dissection made from within the pelvis, after having turned down the bladder from its attachment to the os pubis, and removed a plexus of veins together with the pelvic fascia.

The **COMPRESSOR URETHRÆ** (constrictor urethræ membranaceæ), directed transversely across the perineum above the triangular ligament, *arises* from the ramus of the pubes and ischium, their point of union, and from the anterior ligament of the bladder and prostate gland. Proceeding inwards it divides into two fan-shaped fasciculi, superior and inferior, which embrace the membranous portion of the urethra, and are continuous with the muscle of the opposite side. The *superior fasciculus* is continued forwards to the junction of the crura penis, and backwards to the prostate gland; on the upper surface of which it is spread out. The *inferior fasciculus* is attached to the bulb of the urethra in front, and extends to the prostate gland behind. A third fasciculus, closely united with the two preceding, consists of *circular* fibres, which enclose and form a muscular sheath for the membranous part of the urethra, and are continuous posteriorly with the circular muscular fibres of the prostate gland.

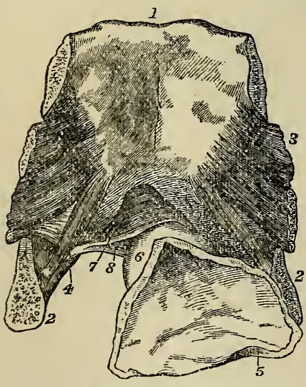


Fig. 204.—Posterior view of the pubes, with part of bladder and urethra attached. 1. Body of pubes. 2. Ramus. 3. Obturator internus muscle. 5. Portion of the fundus and neck of the bladder laid open. 6. Prostate gland. 7. Transverse fibres of the compressor urethræ, passing above the urethra. 8. Similar fibres passing beneath that canal.

Under the name of Wilson's muscles, a fourth fasciculus has been described as descending vertically from the body of the pubes, near the symphysis, to unite with the superior fasciculus of the compressor urethræ. This fasciculus is inconstant and its existence doubtful.

Nerve Supply.—The perineal branch of the pudic.

The **SPHINCTER ANI** is a thin and elliptical plane of muscle closely adherent to the integument, and surrounding the opening of the anus. It *arises* posteriorly in the superficial fascia around the coccyx, and by a fibrous raphé from the apex of that bone ; it passes round the margin of the anus, and is *inserted* anteriorly into the tendinous centre of the perineum, and into the raphé of the integument, nearly as far forward as the commencement of the scrotum.

Relations.—By its *superficial surface* with the integument. By its *deep surface* with the internal sphincter, levator ani, cellular tissue, and fat of the ischio-rectal fossa, and in front with the superficial perineal fascia.

The **SPHINCTER ANI INTERNUS** is a muscular band embracing the extremity of the intestine, and formed by an aggregation of the circular muscular fibres of the rectum ; it is composed of unstriped muscle.

Nerve Supply.—The sphincters are supplied by the anterior branch of the fourth sacral, and inferior hæmorrhoidal branch of the internal pudic.

Dissection.—Part of the levator ani may be seen during the dissection of the anal portion of the perineum by removing the fat which surrounds the termination of the rectum in the ischio-rectal fossa. But to study the entire muscle, a lateral section of the pelvis must be made by sawing through the pubes a little to one side of the symphysis, separating the bones behind at the sacro-iliac symphysis, and turning down the bladder and rectum. The spine of the ischium should be cut off with the bone forceps or saw, so as to leave it in connection with the levator ani and pelvic fascia. The pelvic fascia is then to be carefully raised, beginning at the base of the bladder, and proceeding upwards, until the whole extent of the muscle is exposed.

The **LEVATOR ANI** is a thin plane of muscular fibres, situated at each side of the pelvis. The muscle *arises* from the inner surface of the os pubis near the pubic arch, from the base and upper border of the spine of the ischium, and between those points, from a tendinous arch which occupies the line of division of the pelvic fascia into obturator fascia and recto-vesical fascia. Its fibres descend to be *inserted* into its fellow of the opposite side beneath the prostate gland, into the rectum, and behind the rectum into its fellow of the opposite side and the side of the extremity of the coccyx. Its anterior fibres are sometimes described separately, under the name of *levator prostati.*

In the female this muscle has an additional insertion into the vagina.

Relations.—By its *external* or *perineal surface*, with a thin layer of fascia, by which, and by the obturator fascia, it is separated from the obturator internus muscle ; with the fat in the ischio-rectal fossa, triangular ligament, sphincter ani, and posteriorly, gluteus maximus. By its *internal* or *pelvic surface* with the pelvic fascia, which separates

it from the viscera of the pelvis and peritoneum. No posterior border is continuous with the coccygeus muscle.

Nerve Supply.—The anterior branch of the fourth sacral.

The **COCCYGEUS** muscle, thin and triangular, *arises* from the spine of the ischium and lesser sacro-ischiatic ligament, and spreads out to be *inserted* into the side of the coccyx and lower part of the sacrum.

Relations.—By its *internal* or *pelvic surface* with the cavity of the pelvis and rectum ; by its *external surface* with the lesser sacro-ischiatic ligament ; and by its *borders*, with the pyriformis behind, and levator ani in front.

Nerve Supply.—The fourth and fifth sacral and coccygeal nerves.

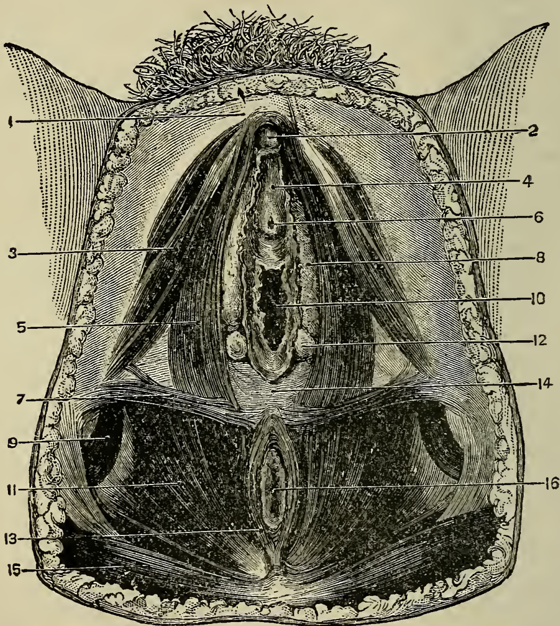


FIG. 205.—Superficial muscles of female perineum. 1. Pubes. 2. Clitoris. 3. Erector clitoridis. 4. Vestibule. 5. Bulbo-cavernous muscle. 6. Urethra. 7. Superficial transverse muscle. 8. Bulb of vagina. 9. Obturator externus muscle. 10. Vagina. 11. Levator ani. 12. Gland of Bartholine. 13. Sphincter ani externus. 14. The perineal body. 15. Gluteus maximus. 16. Anus.

FEMALE PERINEUM.—The muscles of the perineum in the female are the same as in the male, and have received analogous names. They are smaller in size, and are modified to suit the difference of form of the organs ; they are—

Sphincter vaginæ,
Erector clitoridis,
Transversus perinei,
Compressor urethræ,
Sphincter ani,
Levator ani,
Coccygeus.

The **SPHINCTER VAGINÆ** corresponds to the accelerator urinæ of the male; it *arises* from the tendinous centre of the perineum, where it is continuous with the sphincter ani and transversus perinei; and passes forwards on each side of the entrance of the vagina, to be *inserted* into the corpus cavernosum clitoridis, a fasciculus crossing over this structure so as to compress the dorsal vein of the clitoris.

The **ERECTOR CLITORIDIS** *arises* from the ramus of the ischium, and is *inserted* on each side into the crus clitoridis. It is in relation by its inner border with the sphincter vaginæ.

The **TRANSVERSUS PERINEI** is a small muscle *arising* on each side from the ramus of the ischium, and *inserted* into the side of the sphincter vaginæ.

The **COMPRESSOR URETHRÆ** has the same origin and insertion, and exercises the same functions in the female as in the male.

The **SPHINCTER ANI** and **SPHINCTER ANI INTERNUS** surround the lower extremity of the rectum, as in the male.

The **LEVATOR ANI** is *inserted* into the side of the vagina and rectum.

The **COCCYGEUS** is identical with the same muscle in the male.

Nerve Supply.—These muscles are supplied by the same nerves as the corresponding muscles of the male perineum.

Actions.—The *acceleratores urinæ* being continuous at the middle line, and attached at each side to the triangular ligament by means of their posterior fibres, support the bulbous portion of the urethra, and acting forcibly, propel the semen, or the last drops of urine from the canal. The posterior and middle fibres contribute to the erection of the corpus spongiosum, by compressing the venous structure of the bulb; and the anterior fibres assist in the erection of the entire organ by compressing the vena dorsalis, by means of their insertion into the fascia penis. The *erector penis* becomes entitled to its name from spreading out on the dorsum of the organ into a membranous expansion (fascia penis), which compresses the dorsal vein during the action of the muscle, and especially after the erection of the organ has commenced. Erection of the penis results from the retention of the blood in the venous spaces of the corpora cavernosi and corpus spongiosum, that retention being brought about by the compression of the veins of those bodies by the accelerator urinæ and erector penis muscles. The *transverse* muscles serve to steady the tendinous centre, that the muscles attached to it may obtain a firm point of support. According to Cruveilhier, they draw the anus backwards during the expulsion of the fæces, and antagonise the levatores ani,

which carry the anus forwards. The *compressor urethræ*, taking its fixed point from the ramus of the ischium at each side, can compress the urethra so as to close it completely, after the manner of a sphincter. The *external sphincter*, being a cutaneous muscle, contracts the integument around the anus, and by its attachment to the tendinous centre of the perineum and point of the coccyx, assists the levator ani in giving support to the opening during expulsive efforts. The contraction of this muscle is usually involuntary, but may be made more forcible at will. The *internal sphincter* contracts the extremity of the cylinder of the intestine. The use of the *levator ani* is expressed in its name ; it is the antagonist of the diaphragm and abdominal expulsory muscles, and serves to support the rectum and vagina during their expulsive efforts. Yielding to the propulsive action of the abdominal muscles, it enables the outlet of the pelvis to bear a greater force than a resisting structure, and, on the remission of such action, restores the perineum to its original form. Along with the coccygeus it inverts the anal border of the rectum after its protrusion in defæcation. The coccygei muscles restore the coccyx to its natural position, after it has been pressed backwards during defæcation or parturition.

PELVIC FASCIA.

Dissection.—The pelvic fascia may be most conveniently studied by carefully carrying out the following dissection. The muscles attached to the right side of the pubic arch and margin of the obturator foramen are to be completely removed, along with the obturator membrane ; a horizontal cut is then to be made with the saw from the upper margin of the obturator foramen into the acetabulum, and another at the lower margin of the obturator foramen, the two cuts being about an inch apart at the bottom of the acetabulum. These are to be joined by a vertical cut with the chisel, and the pieces of bone removed ; the margins of the obturator foramen are also to be cut away, so as to leave only a narrow ring of bone. The obturator internus may now be detached from adjacent structures, and removed by withdrawing it through the lesser sacro-ischiatic foramen. In this way the whole of the outer surface of the pelvic fascia will be exposed.

The *pelvic fascia* is an aponeurotic layer situated beneath the peritoneum, forming a covering to the walls of the pelvis, and reflected from its walls upon the viscera. It is attached to the internal surface of the pubic bones near the symphysis, to the body of the pubes above the origin of the obturator internus muscle, to the pectineal line of the brim of the pelvis as far back as the sacro-iliac articulation, and to the margin of the great sacro-ischiatic foramen. It is continuous above with the iliac fascia and transversalis fascia. Having descended upon the wall of the pelvis as low as the pubic arch in front, and the spine of the ischium behind, it divides in the

direction of a line drawn between those points into *two* layers, internal and external.

The **external** layer is the **obturator fascia,** it covers in the obturator muscle, and is attached to the ramus of the pubes and ischium in front, and to the tuberosity of the ischium and falciform border of the great sacro-ischiatic ligament below. At its inferior

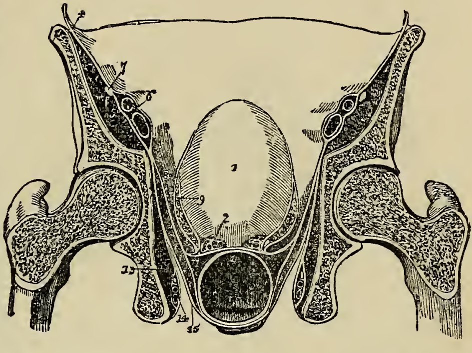


Fig. 206. — Transverse section of the pelvis, seen from behind, showing the distribution of the pelvic fascia. 1. Bladder. 2. Vesicula seminalis of one side divided. 3. Rectum. 4. Iliac fascia, covering in the iliacus and psoas (5); and forming a sheath for the external iliac vessels (6). 7. Anterior crural nerve excluded from the sheath. 8. Pelvic fascia. 9. Its ascending layer, forming the lateral ligament of the bladder of one side, and a sheath to the vesical plexus of veins. 10. Recto-vesical fascia. 11. A layer passing around the rectum. 12. Levator ani. 13. Obturator internus, covered in by the obturator fascia, which also forms a sheath for the internal pudic vessels and nerve (14). 15. Perineal fascia investing the under surface of the levator ani. Figures 14, 15 are placed in the ischio-rectal fossa.

attachment this fascia forms a sheath for the internal pudic vessels and nerves, and binds them down to the ramus of the ischium. The levator ani arises from the line of division of the two layers of the pelvic fascia.

The **internal, visceral,** or **true pelvic fascia,** is a membrane which is reflected backwards from the symphysis pubis on the upper surface of the prostate gland and neck of the bladder, forming part of the capsule of the former. Before passing directly backwards it is prolonged down behind the compressor urethræ muscle below the sub-pubic ligament. This curved reflected fascia is named the anterior ligament of the bladder, and as there is a pouch-like depression in the centre, dividing the fascia of one side from that on the other, each side rises up in a little curved ridge, so that there are two anterior ligaments. The space between the two contains, external to the fascia, the dorsal vein of the penis before it enters the prostatic plexus. At the sides of the pelvis the anterior ligaments are continued back into another part of the pelvic fascia, which is reflected inwards towards the bladder from the line of separation between the two layers referred to. This begins as a strong white band, and is called the lateral ligament of the bladder; it not only reaches the side of the bladder, but is continued over it, although it becomes very thin and is almost lost in the cellular tissue over the apex.

Nevertheless when the bladder is distended it can be traced like a cupola serving in a measure to retain the bladder in its place. From the before-named white line of separation another sheet of the pelvic fascia is given off which hangs down into the pelvis like a bag, and contains in its concavity the curve of the rectum from the sacrum to the anus. Immediately external to this is the levator ani muscle, coated on its outside by another sheet of the pelvic fascia, also given off the same white line. This is termed the *anal fascia.* The bag-like sheet which contains the rectum is sometimes called the *rectal fascia.** Lastly, another sheet is stretched across the pelvis, between the base of the bladder and the rectum, and is called the *recto-vesical fascia.* This sheet is not a complete horizontal septum in the pelvis, but only extends as far back as the posterior limit of the trigone of the bladder, where it is attached to the anterior extremity of the recto-vesical pouch of the peritoneum. The upper two layers of the pelvic fascia are continuous with one another at the front, where they blend and become continuous with the posterior layer of the triangular ligament, but just behind this they have between them the prostate gland, with which they are so closely attached as to form a strong and unyielding capsule. The under

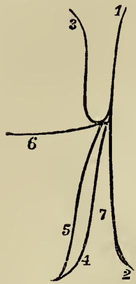


FIG. 207.—Diagram of the layers of pelvic fascia. 1. Pelvic fascia. 2. Obturator. 3. Lateral ligament. 4. Anal. 5. Rectal. 6. Recto-vesical. 7. Ischio-rectal fossa.

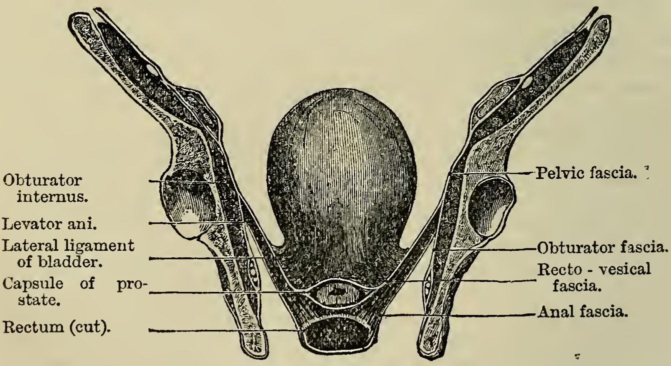


FIG. 208.—Section of pelvis to show the pelvic fascia from the front.

portion of this capsule formed by the anterior half of the recto-vesical fascia is the most important. As far back as the base of the prostate gland it is intimately attached to its fibres, but

* Many anatomists deny the existence of the separate layer here described under the name of *rectal fascia;* it will be noticed that it is shown in Figs. 206 and 207, but is absent from Fig. 208.

behind that spot it is loosely connected with the bladder above and rectum below, a plexus of veins being interposed between it and the bladder above and at the sides, and a very loose areolar tissue between it and the rectum below. A consideration of these relations will explain why an incision in the prostate gland, such as that

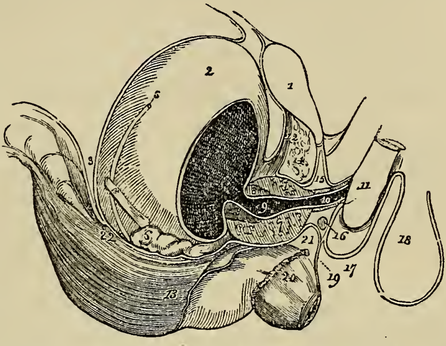


FIG. 209.—Side view of the viscera of the pelvis, showing the distribution of the pelvic fascia. 1. Symphysis pubis. 2. Bladder. 3. Recto-vesical fold of peritoneum, passing from the anterior surface of the rectum to the posterior part of the bladder; and from the upper part of the bladder to the abdominal parietes. 4. Ureter. 5. Vas deferens crossing behind the ureter. 6. Vesicula seminalis. 7, 7, 8, 8. Prostate gland divided longitudinally. 9. Prostatic portion of the urethra. 10. Membranous portion embraced by the compressor urethræ muscle. 11. Commencement of the corpus spongiosum penis, the bulb. 12. Anterior true ligaments of the bladder. 13. The pelvic fascia reflected on the rectum. 14. An interval between the pelvic fascia and triangular ligament occupied by a plexus of veins. 15. The triangular ligament. 16. Cowper's gland. 17. Superficial perineal fascia ascending in front of the root of the penis to become continuous with the dartos of the scrotum (18). 19. The fascia prolonged to the rectum. 20. Lower part of the levator ani. 21. A layer of fascia situated between the bladder and rectum. 22. Longitudinal muscular fibres of rectum.

made in lithotomy, must stop short of complete division of that organ; otherwise it exposes the patient to dangerous venous hæmorrhage from the vesical plexus, or to infiltration of urine among the loose areolar tissue above described.

MUSCLES AND FASCIÆ OF THE UPPER EXTREMITY.

The muscles of the upper extremity may be arranged into groups corresponding with the respective regions of the limb, as follows :—

Anterior Thoracic Region.

Pectoralis major,
Pectoralis minor,
Subclavius.

Lateral Thoracic Region.

Serratus magnus.

Anterior Scapular Region.

Subscapularis.

Posterior Scapular Region.

Supra-spinatus,
Infra-spinatus,
Teres minor,
Teres major.

Acromial Region.

Deltoid.

Anterior Humeral Region.

Coraco-brachialis,
Biceps,
Brachialis anticus.

Posterior Humeral Region.

Triceps.

Anterior Brachial Region.

Superficial Layer.

Pronator radii teres,
Flexor carpi radialis,
Palmaris longus,
Flexor sublimis digitorum,
Flexor carpi ulnaris.

Deep Layer.

Flexor profundus digitorum,
Flexor longus pollicis,
Pronator quadratus.

Posterior Brachial Region.

Superficial Layer.

Supinator longus,
Extensor carpi radialis longior,
Extensor carpi radialis brevior,
Extensor communis digitorum,
Extensor minimi digiti,
Extensor carpi ulnaris,
Anconeus.

Deep Layer.

Supinator brevis,
Extensor ossis metacarpi pollicis,
Extensor primi internodii pollicis,
Extensor secundi internodii poll.,
Extensor indicis.

Hand.

Radial Region (Thenar).

Abductor pollicis,
Flexor ossis metacarpi (opponens),
Flexor brevis pollicis,
Adductor pollicis.

Ulnar Region (Hypothenar).

Palmaris brevis,
Abductor minimi digiti,
Flexor brevis minimi digiti,
Flexor ossis metacarpi.

Palmar Region.

Lumbricales, Palmar interossei, Dorsal interossei.

FASCIÆ OF THE UPPER EXTREMITY.

The **superficial fascia** of the upper extremity contains between its layers the superficial veins and lymphatics, and superficial nerves.

The **deep fascia** is thin over the deltoid and pectoralis major muscle, and in the axillary space, but thick on the dorsum of the scapula, where it binds down the infra-spinatus muscle. It is attached to the clavicle, coracoid process, acromion process, and spine of the scapula, and forms separate sheaths for all the muscles of the scapula and shoulder. In the *upper arm* it is somewhat stronger,

receives fibres from the lower border of the tendon of the pectoralis major, latissimus dorsi, as also from the costo-coracoid membrane and deltoid, and forms an anterior and posterior sheath for the muscles lying in front of and behind the humerus. It is attached to the condylar ridges, by means of the **internal** and **external intermuscular septum** and is inserted inferiorly into the two condyles, the olecranon, and posterior border of the ulna, being continuous between these points with the fascia of the forearm. Besides forming separate sheaths for the muscles, the anterior portion of the brachial fascia gives a sheath likewise to the brachial vessels and median nerve.

The intermuscular septa serve to separate the muscles on the back from those on the front of the upper arm, and also give an increased area for the attachment of those muscles. The external septum is pierced from behind forwards by the musculo-spiral nerve and superior profunda artery; the internal is pierced from before backwards by the ulnar nerve and inferior profunda and anastomotica arteries.

The deep fascia of the forearm is strong, and at the bend of the elbow is augmented in thickness by a broad band, which is given off from the inner side of the tendon of the biceps. It is firmly attached to the olecranon process, to the ulna, and to the prominent points about the wrist, forms sheaths for the muscles and vessels, gives origin to some of the fibres of the muscles, and is pierced a little above the wrist by the tendon of the palmaris longus. At the wrist the transverse fibres form the anterior and posterior annular ligament.

The **anterior annular ligament** is a narrow band of fibres attached externally to the scaphoid, and internally to the pisiform bone and tendon of the flexor carpi ulnaris; it is continuous above with the deep fascia of the forearm, and below with the palmar fascia. It is connected with the tendons of the palmaris longus and flexor carpi ulnaris, and gives origin to certain of the muscles of the thumb and little finger. The ulnar vessels and nerve, and the cutaneous branches of the median nerve, lie superficially to it. The ligament is pierced by the tendon of the flexor carpi radialis, and forms with the carpal bones a canal which is lined by synovial membrane, and gives passage to the tendons going to the fingers. The synovial sheath is divided into a large and a small compartment, the former transmitting the flexor sublimis and profundus tendons and the median nerve, the latter enclosing the tendon of the flexor longus pollicis.

The **posterior annular ligament** is an oblique band about half an inch in breadth, extending from the lower end and styloid process of the radius to the cuneiform and pisiform bone at the border of the carpus. It is continuous above with the fascia of the forearm, below with the thin fascia of the dorsum of the hand, and sends processes inwards to be attached to the bones and form sheaths for the extensor tendons. There are six of these sheaths, the first on the radial side giving passage to the extensor ossis metacarpi and

extensor primi internodii pollicis; the second, to the extensor carpi radialis longior and brevior; the third, to the extensor secundi internodii; the fourth, to the extensor indicis and extensor communis digitorum; the fifth, which is placed between the two bones, to the extensor minimi digiti; and the sixth, situated on the ulna, to the extensor carpi ulnaris. The tendons in passing through these sheaths are each provided with a synovial bursa.

On the back of the hand there are two fasciæ, superficial and deep. The *superficial dorsal fascia* is thin and covers in the extensor tendons; it is attached laterally to the metacarpal bones of the index and little finger, and is continuous above with the posterior annular ligament. The *deep dorsal fascia* is stretched across the metacarpal spaces and covers in the interossei muscles.

The **palmar fascia** is divided into three portions. A central portion, which occupies the middle of the palm, and two lateral portions, which are thin and enclose the muscles of the borders of the hand, being continuous with the dorsal fascia. The central portion is strong and tendinous: it is narrow at the wrist, where it is attached to the annular ligament and receives the insertion of the tendon of the palmaris longus, and broad over the heads of the metacarpal bones, where it divides into four processes, each of which subdivides to embrace the root of the corresponding finger. These processes are attached at the middle line to the sheath of the tendons, and at the side of each finger to the lateral and transverse ligament. The fascia is strengthened at this point of division by strong fasciculi of transverse fibres; the arched interval caused by the bifurcation of each slip gives passage to the tendons of the flexor muscles, while the greater arches between the fingers transmit the digital vessels and nerves, and lumbricales muscles.

Anterior Thoracic Region.

Dissection.—Make an incision along the line of the clavicle, from the upper part of the sternum to the acromion process, and thence down the arm as far as the level of the lower border of the latissimus dorsi; a second carried transversely outwards from the base of the ensiform cartilage to the posterior border of the axilla; and connect the two by a third, carried longitudinally along the middle of the sternum. The integument and superficial fascia are to be dissected separately from off the fibres of the muscle, and always in the direction of their course. For this purpose the dissector, if he have the right arm, will commence with the lower angle of the flap; if the left, with the upper angle. He will thus expose the pectoralis major muscle in its whole extent.

Pectoralis major, Pectoralis minor, Subclavius.

The **PECTORALIS MAJOR** *arises* from the sternal half of the clavicle, from half the sternum its whole length, from the cartilages

of all the true ribs, excepting the first and last, and from the aponeurosis of the external oblique muscle of the abdomen. From this extensive origin the fibres converge to be *inserted* by a broad and folded tendon into the external bicipital ridge of the humerus.

The pectoralis major admits of division into three portions, *clavicular*, *sternal*, and *costal;* the two former are separated from each other by a well-marked cellular interspace; the latter is distinguished not only by its origin, but also by forming a fold beneath the sternal portion, and lying behind it at its insertion. At the latter point the three portions are superimposed, the clavicular being in front, the sternal next, the costal behind; the clavicular portion being prolonged at its insertion to the lower extremity of the bicipital ridge, the costal portion to its upper end. The clavicular portion, which arises highest up, is inserted lowest down, and the costal portion which arises lowest is inserted highest on the humerus.

Relations.—By its *external surface* with the fibres of origin of the platysma myoides, mammary gland, superficial fascia, and integument. By its *internal surface*, on the thorax, with the clavicle, sternum, costal cartilages, intercostal muscles, subclavius, pectoralis minor, and serratus magnus; in the axilla, with the axillary vessels and glands. By its *external border* with the deltoid, from which it is separated above by a cellular interspace lodging the cephalic vein and descending branch of the thoracico-acromialis artery. Its *lower border* forms the anterior boundary of the axillary space.

Nerve Supply.—External and internal anterior thoracic branches of the brachial plexus.

Dissection.—The pectoralis major is to be removed by dividing its fibres along the lower border of the clavicle, and then carrying the incision perpendicularly downwards, parallel to the sternum, and at about three inches from its border. Divide some loose cellular tissue, and several small branches of the thoracic arteries, and reflect the muscle outwards. We thus bring into view a region of considerable interest, in the middle of which is situated the pectoralis minor.

The **PECTORALIS MINOR** *arises* by three digitations from the front and upper border of the third, fourth, and fifth ribs near their cartilages, and from the intercostal fascia; and is *inserted* by a broad tendon into the anterior border of the coracoid process of the scapula. It is closely united at its insertion with the coraco-brachialis.

Relations.—By its *anterior surface* with the pectoralis major and superior thoracic vessels and nerves. By its *posterior surface* with the ribs, intercostal muscles, serratus magnus, axillary space, and axillary vessels and nerves. Its *upper border* forms the lower boundary of a triangular space, bounded above by the costo-coracoid membrane, and internally by the ribs; in this space are found the axillary vessels and nerves.

Nerve Supply.—Internal anterior thoracic from the inner cord of the brachial plexus.

Costo-coracoid Membrane.—In order to see the next muscle it is necessary to remove a strong sheet of fascia which covers it in; this is called the costo-coracoid membrane. It is a process of deep cervical fascia which, passing beneath the clavicle, encloses the subclavius, and is stretched across from the cartilage of the first rib to the coracoid process. It becomes thinner as it passes downwards, and may be traced in front of the axillary vessels, where it blends with their sheath.

The **SUBCLAVIUS** *arises* by a round tendon from the cartilage and adjacent osseous part of the first rib; it is *inserted* into the under surface of the clavicle near the coraco-clavicular ligament. It lies in a groove on the inferior aspect of the clavicle.

Relations.—By its *upper surface* with the clavicle. By the *lower* with the subclavian artery and vein and brachial plexus, which separate it from the first rib. In *front* with the pectoralis major, the costo-coracoid membrane being interposed.

Nerve Supply.—A branch from the fifth and sixth cervical.

Actions.—The pectoralis major draws the arm across the thorax, while its upper fibres assist the upper part of the trapezius in raising the shoulder, as in supporting weights. The lower fibres depress the shoulder with the aid of the latissimus dorsi. Taking its fixed point from the shoulder, the pectoralis major assists the pectoralis minor, subclavius, and serratus magnus, in drawing up and expanding the chest. The pectoralis minor, in addition to this action, draws upon the coracoid process, and assists in rotating the scapula upon the chest. The subclavius draws the clavicle downwards and forwards, and thereby assists in steadying the shoulder. All the muscles of this group are agents in forced inspiration, but are incapable of acting in that capacity until the shoulders are fixed.

Lateral Thoracic Region.

Serratus Magnus.

The **SERRATUS MAGNUS** (*serratus*, indented like the edge of a saw), broad, thin, and trapezoid in shape, *arises* by nine fleshy serrations from the eight upper ribs, two of the serrations being attached to the second rib, and extends backwards upon the side of the chest, to be *inserted* into the whole length of the base of the scapula, its anterior aspect. In structure, the muscle is composed of three portions: *superior*, formed by the first and second serrations and inserted into the inner surface of the superior angle of the scapula; *middle*, composed of the third and fourth serrations and inserted into the greater part of the posterior border; *inferior*, consisting of the last five serrations; these latter indigitate with the obliquus externus and form a thick muscular fasiculus, which is inserted into the scapula near its inferior angle.

Relations.—By its *superficial surface* with the pectoralis major and minor, subscapularis, latissimus dorsi, and axillary vessels and

nerves. By its *deep surface* with the ribs and intercostal muscles, to which it is connected by loose cellular tissue.

Nerve Supply.—External respiratory (posterior thoracic) nerve, from the fifth and sixth cervical.

Actions.—The serratus magnus is the great muscle of forced inspiration, raising the ribs when the shoulders are fixed, and thereby increasing the cavity of the chest. By drawing the scapula forwards it allows of the further outstretching of the arm after it has been raised, as in the action called extension in fencing. Along with the trapezius it rotates the scapula so as to project its inferior angle, and thus assists in raising the arm above the level of the shoulder. It is also of service in all movements of pushing.

Anterior Scapular Region.

Subscapularis.

The **SUBSCAPULARIS** *arises* from the whole of the under surface of the scapula excepting the superior and inferior angle and posterior border, and terminates by a broad and thick tendon, which is *inserted* into the lesser tuberosity of the humerus, and by muscular fibres into the surface of bone immediately below that process. In structure the subscapularis is composed of eight or ten fasciculi, four or five of which *arise* from one side of as many aponeurotic processes attached to the ridges of the venter of the scapula; and four or five proceed from the other side of the aponeurotic processes and from the surface of bone intervening between them. Its tendon forms part of the capsule of the joint, glides over a large bursa which separates it from the base of the coracoid process, and is lined by a prolongation of the synovial membrane of the articulation.

Relations.—By its *anterior surface* with the serratus magnus, coraco-brachialis, and axillary vessels and nerves. By its *posterior surface* with the scapula and shoulder-joint.

Nerve Supply.—The short and middle subscapular nerves, branches from the posterior cord of the brachial plexus.

Action.—It rotates the head of the humerus inwards, and is a powerful defence to the joint. When the arm is raised, it draws the humerus downwards.

Posterior Scapular Region.

Supra-spinatus,	Teres minor,
Infra-spinatus,	Teres major.

The **SUPRA-SPINATUS** muscle (*supra*, above; *spina*, the spine) *arises* from the supra-spinous fossa, spine of the scapula, and proper investing fascia; and is *inserted* into the uppermost depression on the greater tuberosity of the humerus, the tendon being united near its attachment with that of the infra-spinatus. The tendon cannot be seen until the acromion process is removed.

Relations.—By its *upper surface* with the trapezius, clavicle,

acromion, and coraco-acromial ligament. From the trapezius it is separated by a strong fascia. By its *lower surface* with the supra-spinous fossa, supra-scapular vessels and nerve, origin of the omo-hyoid muscle, and upper part of the shoulder-joint.

Nerve Supply.—The supra-scapular nerve, a branch from the fifth and sixth cervical.

The **INFRA-SPINATUS** (*infra*, beneath ; *spina*, the spine) is covered in by a layer of tendinous fascia, which must be removed before the fibres of the muscle can be seen, the deltoid muscle having been previously turned down from its scapular origin. It *arises* from the whole of the infra-spinous fossa, excepting the inferior angle and axillary border, and a small portion near the neck of the bone, from the spine of the scapula, and from the investing fascia ; it is *inserted* into the middle depression of the greater tuberosity of the humerus, its tendon being blended with that of the supra-spinatus above and the teres minor below.

Relations.—By its *posterior surface* with the deltoid, latissimus dorsi, trapezius, and integument. By its *anterior surface* with the infra-spinous fossa, supra-scapular and dorsal scapular vessels, and shoulder-joint. By its *upper* border it is in relation with the spine of the scapula, and by the *lower* with the teres major and minor, being closely united with the latter.

Nerve Supply.—The supra-scapular nerve.

The **TERES MINOR** (*teres*, round) *arises* from the posterior surface of the axillary border of the scapula for about the middle third of its extent ; it is connected with the lower border of the preceding muscle, and is *inserted* into the inferior depression of the greater tuberosity of the humerus. The tendons of the three preceding muscles are in immediate contact with the shoulder-joint, and are the structures most frequently ruptured in dislocation of the head of the humerus.

Relations.—By its *posterior surface* with the deltoid and integument. By its *anterior surface* with the inferior border and part of the dorsum of the scapula, dorsalis scapulæ vessels, scapular head of the triceps, and shoulder-joint. By its *upper border* with the infra-spinatus ; by the *lower* with the teres major, and long head of the triceps.

Nerve Supply.—A branch of the circumflex nerve. This branch is distinguished by a ganglionic enlargement, just before it enters the muscle.

The **TERES MAJOR** muscle *arises* from the dorsal surface of the inferior angle of the scapula, and from its axillary border ; it is *inserted* into the internal bicipital ridge of the humerus, immediately behind the tendon of the latissimus dorsi. At its origin this muscle is covered by the latissimus dorsi, but the latter shortly afterwards curves around its lower border and becomes placed in front ; the two tendons at their insertion, one lying behind the other, are separated by a bursa.

Relations.—By its *posterior surface* with the latissimus dorsi, scapular head of the triceps, and integument. By its *anterior surface*

with the subscapularis, latissimus dorsi, coraco-brachialis, short head of the biceps, axillary vessels, and nerves of the brachial plexus. By its *upper* border it is in relation with the teres minor, from which it is separated by the scapular head of the triceps; and, by the *lower*, forms, with the latissimus dorsi, the lower and posterior border of the axilla.

Nerve Supply.—Middle and long subscapular branches derived from the posterior cord of the brachial plexus.

Triangular and Quadrangular Spaces.—A large triangular space exists between the two teres muscles, which is divided into two minor spaces by the long head of the triceps. The smaller of the two spaces is placed posteriorly; it is triangular in form, being bounded above by the teres minor, below by the teres major, and in front by the long head of the triceps. It gives passage to the dorsalis scapulæ vessels. The anterior space is quadrangular, and is bounded above by the teres minor, below by the teres major, in front by the humerus, and behind by the long head of the triceps; it transmits the posterior circumflex vessels and circumflex nerve.

Actions.—The supra-spinatus raises the arm from the side; but feebly, from the disadvantageous direction of its force. The infra-spinatus and teres minor are rotators of the head of the humerus outwards. The most important use of these three muscles is the protection of the joint, and defence against displacement of the head of the humerus, in which action they co-operate with the sub-scapularis. The teres major combines with the latissimus dorsi in rotating the arm inwards, and at the same time carrying it towards the side, and somewhat backwards.

Acromial Region.

Deltoid.

The **DELTOID** (Δ, delta; εἶδος, like) is the large triangular muscle which forms the convexity of the shoulder; it *arises* from the outer third of the clavicle, from the acromion process, and from the whole length of the lower border of the spine of the scapula. The fibres from this broad origin converge to the middle of the outer side of the humerus, where they are *inserted* into a rough triangular elevation. In structure the deltoid is composed of seven fasciculi, four of which are fleshy above and tendinous below; and three tendinous above and fleshy below. To bring the muscles beneath it into view, the deltoid must be cut away from its origin, and turned down; in so doing, a large bursa will be seen between its under surface and the head of the humerus.

Relations.—By its *superficial surface* with the deep fascia, a few fibres of the platysma myoides, the superficial fascia, and integument. By its *deep surface* with the shoulder-joint (from which it is separated by a thin tendinous fascia and a synovial bursa), the coraco-acromial ligament, coracoid process, pectoralis minor, coraco-brachialis, both heads of the biceps, tendon of the pectoralis major,

tendon of the supra-spinatus, infra-spinatus, teres minor, teres major, scapular and external head of the triceps, circumflex vessels anterior and posterior, and humerus. By its *anterior border* with the external border of the pectoralis major, from which it is separated by an interspace, lodging the cephalic vein and descending branch of the thoracico-acromialis artery. Its *posterior border* is thin and tendinous above, where it is connected with the aponeurotic covering of the infra-spinatus muscle, and thick below.

Nerve Supply.—The circumflex nerve, from the posterior cord of the brachial plexus.

Actions.—The deltoid is the elevator muscle of the arm in a direct line, and, by means of its extensive origin, it can carry the arm forwards or backwards so as to range with the hand a considerable segment of a large circle. The arm, raised by the deltoid, is an illustration of a lever of the *third* power, so common in the animal machine, by which velocity is gained at the expense of power. In this lever, the weight (hand) is at one extremity, the fulcrum (glenoid cavity) at the opposite end, the power (insertion of the muscle) between the two, but nearer to the fulcrum than to the weight.

Anterior Humeral Region.

Coraco-brachialis, Biceps brachii, Brachialis anticus.

Dissection.—These muscles are exposed on the removal of the integument and fascia from the anterior half of the upper arm, and the clearing away of the areolar tissue.

The **CORACO-BRACHIALIS**, a name suggestive of its points of origin and insertion, *arises* from the apex of the coracoid process in common with the short head of the biceps; and is *inserted* into a smooth impression on the inner side of the middle of the humerus.

Relations.—By its *anterior surface* with the deltoid and pectoralis major. By its *posterior surface* with the shoulder-joint, humerus, subscapularis, teres major, latissimus dorsi, short head of the triceps, and anterior circumflex vessels. By its *internal border* with the axillary and brachial vessels and nerves, particularly with the median and musculo-cutaneous nerve, by the latter of which it is pierced. By the *external border* with the short head of the biceps and brachialis anticus.

Nerve Supply.—The external cutaneous nerve which pierces it about its middle.

The **BICEPS BRACHII** (*bis—caput*, two heads; flexor cubiti) *arises* by two tendons: one, the *short head*, from the coracoid process in common with the coraco-brachialis; the other, the *long head*, from the upper part of the glenoid cavity, where it is continuous with the glenoid ligament. The muscle is *inserted* by a flattened tendon into the back part of the tubercle of the radius. The long head, a long slender tendon, passes through the capsular ligament of the shoulder-joint enclosed in a sheath of the synovial membrane;

after leaving the cavity of the joint, it is lodged in the deep groove that separates the two tuberosities of the humerus, the bicipital groove. A small synovial bursa is interposed between the tendon of insertion and the tubercle of the radius. At *the bend* of the elbow, the tendon of the biceps gives off from its inner side a tendinous band, which spreads out to form a sheet of fascia called the *semilunar* or *bicipital fascia*; it protects the brachial artery, and is continuous with the fascia of the forearm.

Fig. 210.—Muscles of the anterior aspect of the upper arm. 1. Coracoid process of the scapula. 2. Coraco-clavicular ligament (trapezoid), passing upwards to the scapular end of the clavicle. 3. Coraco-acromial ligament, passing outwards to the acromion. 4. Subscapularis. 5. Teres major; the triangular space above this muscle is that through which the dorsalis scapulæ vessels pass. 6. Coraco-brachialis. 7. Biceps. 8. Upper end of the radius. 9. Brachialis anticus; a portion of the muscle is seen at the outer side of the tendon of the biceps. 10. Internal head of the triceps.

The biceps occasionally has a third head, connected with the humerus; this most frequently arises from the shaft of that bone in connection with the insertion of the coraco-brachialis and origin of the brachialis anticus, and is inserted into the back part of the bicipital fascia and inferior tendon of the muscle.

Relations.—By its *anterior surface* with the deltoid, pectoralis major, superficial and deep fascia, and integument. By its *posterior surface* the short head rests on the subscapularis, from which it is separated by a bursa. In the rest of its extent the muscle is in relation with the humerus, teres major, latissimus dorsi, and brachialis anticus; from the latter it is separated by the musculo-cutaneous nerve. By its *inner border* with the coraco-brachialis, brachial artery and veins, and median nerve; the brachial vessels crossing its tendon at the bend of the elbow. By its *outer border*, with the deltoid and supinator longus.

Nerve Supply.—The external or muscular cutaneous nerve.

The **BRACHIALIS ANTICUS** is a broad muscle covering the whole of the anterior surface of the lower part of the humerus; it *arises* by two fleshy serrations, which embrace the insertion of the deltoid, from the anterior surface of the humerus, and from the inner intermuscular septum. Its fibres converge to be *inserted* into the base of the coronoid process of the ulna, between two processes of the flexor profundus digitorum.

Relations.—By its *anterior surface* with the biceps, musculo-cutaneous nerve, brachial artery and veins, and median nerve. By its *posterior surface* with the humerus, anterior ligament of the elbow-joint, and intermuscular septum. The latter separates it from the triceps. By its *external border* with the supinator longus, extensor carpi radialis longior, musculo-spiral nerve, and recurrent radial artery. By its *internal border* with the intermuscular septum (which separates it from the triceps and ulnar nerve), and with the pronator radii teres.

Nerve Supply.—The musculo-cutaneous and musculo-spiral nerves.

Actions.—The coraco-brachialis draws the humerus inwards, and assists in flexing it upon the scapula. The biceps is one of the chief flexors of the elbow-joint; it is also an important supinator, this action resulting from the attachment of the tendon to the *back* part of the tubercle of the radius. It makes tense the fascia of the forearm, and so assists the muscles connected with the fascia. Its long tendon passing through the shoulder-joint acts as a ligament, keeping the head of the humerus in its place, and the same tendon, where it lies in the bicipital groove, limits the outward rotation of the humerus in supination, by pressing against the lesser tuberosity. Lastly, the biceps acts as an extensor of the arm at the shoulder, assisting the deltoid. The brachialis anticus is a powerful flexor of the elbow, and in some measure supplies the place of an anterior ligament to that joint.

Posterior Humeral Region.

Triceps brachii.

Dissection.—Remove the integument and fascia from the posterior aspect of the upper arm.

The **TRICEPS BRACHII** (having three heads; triceps extensor cubiti) *arises* by three heads: external, middle, and internal.

The *external* head arises from the outer part of the posterior surface of the humerus in a line extending from the insertion of the teres minor to the musculo-spiral groove, and from a tendinous arch derived from the upper part of the external intermuscular septum and bridging over the upper part of the groove. The *internal* head is attached to the inner margin of the humerus below the insertion of the teres major, to the whole of the posterior surface of the bone below the musculo-spiral groove to the back of the internal condyle and posterior aspect of both external and internal intermuscular septum. The *middle* or *long* head arises by a tendon from the ridge below the glenoid cavity of the scapula and the adjoining rough portion of that bone. The three heads, passing downwards in different directions, unite to form a broad muscle, which is *inserted* into the olecranon process of the ulna, and sends an expansion to the deep fascia of the forearm. A small bursa is situated between the tendon of the muscle and the upper part of the olecranon.

Beneath the lower part of the triceps are two small fasciculi *arising* from the humerus, and descending one on either side of the fossa of the olecranon to be *inserted* into the capsule of the elbow-joint. These have been named **sub-anconeus**; they are analogous to the sub-crureus.

Relations.—By its *posterior surface* with the deep and superficial fascia and integument. By its *anterior surface* with the superior profunda artery, musculo-spiral nerve, humerus, intermuscular septa which separate it from the brachialis anticus and elbow-joint. The *scapular head* is in relation posteriorly with the deltoid and teres minor; anteriorly with the subscapularis, teres major, and latissimus dorsi; and externally with the posterior circumflex vessels and nerve.

Nerve Supply.—The musculo-spiral nerve.

Actions.—The triceps brachii is an extensor of the forearm.

FIG. 211.—Posterior view of the upper arm, and triceps muscle. 1. External head. 2. Long or scapular head. 3. Internal or short head. 4. Olecranon process of ulna. 5. Radius. 6. Capsular ligament of the shoulder-joint.

Anterior Brachial Region.

Superficial Layer.

Pronator radii teres,
Flexor carpi radialis,
Palmaris longus,
Flexor sublimis digitorum,
Flexor carpi ulnaris.

Dissection. — These muscles are brought into view by making an incision through the integument along the middle line of the forearm, crossing each extremity by a transverse incision, and turning aside the flaps. The superficial and deep fascia are then to be removed.

The **PRONATOR RADII TERES** *arises* by two heads: one from the inner condyle of the humerus, fascia of the forearm, and intermuscular septum; the other from the coronoid process of the ulna; the median nerve passing between them. Its tendon is flat, and is *inserted* into the middle of the outer side of the shaft of the radius. The two heads of this muscle are best examined by cutting through that which arises from the inner condyle, and turning it aside. The second head will then be seen with the median nerve lying across it.

Relations.—By its *anterior surface* with the deep fascia of the forearm, supinator longus, extensor carpi radialis longior and brevior,

radial artery and veins, and radial nerve. By its *posterior surface* with the brachialis anticus, flexor sublimis digitorum, ulnar artery and veins, and the median nerve after it has passed between the two heads of the muscle. By its *upper border* it forms the inner boundary of the triangular space, in which the termination of the brachial artery is situated. By its *lower border* it is in relation with the flexor carpi radialis.

Nerve Supply.—Median nerve.

FIG. 212. — Superficial layer of muscles of the forearm. 1. Biceps, with its tendon. 2. Brachialis anticus, seen beneath biceps. 3. Part of triceps. 4. Pronator radii teres. 5. Flexor carpi radialis. 6. Palmaris longus. 7. One of the fasciculi of the flexor sublimis digitorum; the rest of the muscle is seen beneath the tendons of the palmaris longus and flexor carpi radialis. 8. Flexor carpi ulnaris. 9. Palmar fascia. 10. Palmaris brevis. 11. Abductor pollicis. 12. Flexor brevis pollicis; the leading line crosses part of the adductor pollicis. 13. Supinator longus. 14. Extensor ossis metacarpi and extensor primi internodii pollicis, curving around the lower border of the forearm.

The **FLEXOR CARPI RADIALIS** *arises* from the inner condyle, deep fascia, and intermuscular septa. Its tendon perforates the anterior annular ligament, and passes through a groove in the trapezium bone, to be *inserted* into the base of the metacarpal bone of the index finger.

Relations.—By its *anterior surface* with the deep fascia of the forearm, and at the wrist with the tendinous canal through which its tendon passes. By its *posterior surface* with the flexor sublimis digitorum, flexor longus pollicis, wrist-joint, and groove in the trapezium bone. By its *outer border* with the pronator radii teres, radial artery and veins. By its *inner border* with the palmaris longus. The tendon is surrounded by synovial membrane, where it plays through the tendinous canal of the wrist.

Nerve Supply.—Median nerve.

The **PALMARIS LONGUS** is a small muscle which *arises* from the inner condyle, deep fascia, and intermuscular septa. Its tendon pierces the deep fascia and crosses the annular ligament to be *inserted* into the palmar fascia.

Relations.—By its *anterior surface* with the deep fascia of the forearm. By the *posterior surface* with the flexor sublimis digitorum; to the *external side* with the flexor carpi radialis; and to the *internal side* with the flexor carpi ulnaris.

Nerve Supply.—Median nerve.

Dissection.—Cut the flexor carpi radialis and palmaris longus

from their origin, in order to obtain a good view of the whole extent of origin of the flexor sublimis digitorum.

The **FLEXOR SUBLIMIS DIGITORUM** (perforatus) *arises* from the inner condyle, intermuscular septa, internal lateral ligament, coronoid process of the ulna, and oblique line of the radius. The median nerve and ulnar artery pass between its heads. It divides into four tendons, which pass beneath the annular ligament, and are *inserted* into the base of the second phalanges of the fingers, splitting at their termination to give passage to the tendons of the deep flexor; hence its designation, *perforatus.* The tendons pass beneath the annular ligament arranged in pairs, those for the middle and ring fingers being placed superficially, and those for the index and little fingers beneath them. At the bases of the first phalanges the flexor tendons enter small canals which are in part formed by the grooved surfaces of the bones, and in part by fibrous arches thrown across the tendons; these are called *thecæ* (*θήκα*, a case). In the thecæ of the fingers several small tendinous fasciculi are found, which pass from the phalanges to the edges of the tendons; these have been termed the *vincula accessoria.*

Relations.—In the forearm: by its *anterior surface* with the pronator radii teres, flexor carpii radialis, palmaris longus, flexor carpi ulnaris, and the deep fascia. By its *posterior surface* with the flexor profundus digitorum, flexor longus pollicis, ulnar artery, veins, and nerve, and median nerve. This muscle frequently sends a fasciculus to the flexor longus pollicis or flexor profundus. In the hand: its tendons, after passing beneath the annular ligament, are in relation *superficially* with the superficial palmar arch, and palmar fascia; and *deeply* with the tendons of the deep flexor and lumbricales.

Nerve Supply.—Median nerve.

The **FLEXOR CARPI ULNARIS** *arises* by two heads, one from the inner condyle and intermuscular septa, the other from the olecranon and by means of a strong aponeurosis from two-thirds of the posterior border of the ulna. Its tendon is *inserted* into the pisiform bone, anterior annular ligament, and base of the metacarpal bone of the little finger.

Relations.—By its *anterior surface* with the deep fascia of the forearm, with which it is closely united superiorly. By its *posterior surface* with the flexor sublimis digitorum, flexor profundus, pronator quadratus, ulnar artery, veins, and nerve. By its *radial border*, with the palmaris longus, and in the lower third of the forearm, the ulnar vessels and nerve. The ulnar nerve, and the posterior ulnar recurrent artery, pass between its two heads of origin.

Nerve Supply.—Ulnar nerve.

Deep Layer.

Flexor profundus digitorum, Flexor longus pollicis,
Pronator quadratus.

Dissection.—This group is brought into view by removing the flexor sublimis, and drawing aside the pronator radii teres.

The **FLEXOR PROFUNDUS DIGITORUM** (perforans) *arises* from the upper two-thirds of the ulna, its anterior and inner surface and posterior border, from the inner side of the olecranon, where it is connected with the aponeurotic expansion of the flexor carpi ulnaris, and from the ulnar half of the interosseous membrane. At the middle of the forearm it divides into four tendons which pass beneath the annular ligament, and along the fingers, between the two slips of the tendons of the flexor sublimis, to be *inserted* into the base of the last phalanges. In the groove of the carpus the tendons are enclosed in a synovial membrane, and the three outer tendons communicate with each other by means of small slips, the tendon of the index finger remaining distinct. In the hand, the tendons give origin to the lumbricales muscles, and on the second phalanges are retained in position by two little tendinous slips, the vincula accessoria.

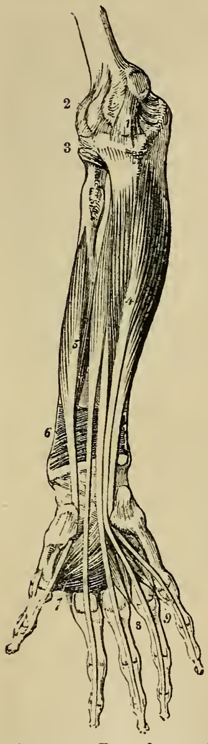


FIG. 213.—Deep layer of muscles of the forearm. 1. Internal lateral ligament of the elbow-joint. 2. Anterior ligament. 3. Orbicular ligament of the head of the radius. 4. Flexor profundus digitorum. 5. Flexor longus pollicis. 6. Pronator quadratus. 7. Adductor pollicis. 8. Dorsal interosseous of the middle, and palmar interosseous of the ring finger. 9. Dorsal interosseous muscle of the ring finger, and palmar interosseous of the little finger.

Relations.—In the forearm: by its *anterior surface* with the flexor sublimis digitorum, flexor carpi ulnaris, median nerve, and ulnar artery, veins, and nerve. By its *posterior surface* with the ulna, interosseous membrane, pronator quadratus, and wrist-joint. By its *radial border* with the flexor longus pollicis, the anterior interosseous artery and nerve being interposed. By its *ulnar border* with the flexor carpi ulnaris. In the hand: its tendons are in relation *superficially* with the tendons of the superficial flexor; and *deeply* with the interossei, adductor pollicis, and deep palmar arch.

Nerve Supply.—Median and ulnar nerves.

The **FLEXOR LONGUS POLLICIS** *arises* from the anterior surface of the shaft of the radius for two-thirds of its extent, and from one-half the interosseous membrane. Its tendon passes beneath the annular ligament to be *inserted* into the base of the last phalanx of the thumb.

Relations.—By its *anterior surface* with the flexor sublimis digitorum, flexor carpi radialis, supinator longus, and radial artery and veins. By its *posterior surface* with the radius, interosseous membrane, pronator quadratus, and wrist-joint. By its *ulnar border*, it is separated from the flexor profundus digi-

torum by the anterior interosseous artery and nerve. In the hand: after passing beneath the annular ligament, it is lodged in the interspace between the two portions of the flexor brevis pollicis, and afterwards in the tendinous theca of the phalanx.

Nerve Supply.—Anterior interosseous, a branch of the median.

Dissection.—If the tendons of the last two muscles be drawn aside or divided, the third muscle of this group will be brought into view, lying across the lower part of the two bones.

The **PRONATOR QUADRATUS** *arises* from the anterior and inner side of the ulna, and is *inserted* into the front of the radius. This muscle occupies about the lower fourth of the two bones, is broad at its origin, and narrower at its insertion.

Relations.—By its *anterior surface* with the tendons of the supinator longus, flexor carpi radialis, flexor longus pollicis, flexor profundus digitorum, and flexor carpi ulnaris, radial artery and veins, and ulnar artery, veins, and nerve. By its *posterior surface* with the radius, ulna, and interosseous membrane.

Nerve Supply.—Anterior interosseous, a branch of the median.

Actions.—The pronator radii teres and pronator quadratus rotate the radius upon the ulna, and render the hand prone. The remaining muscles are flexors: two flexors of the wrist, flexor carpi radialis and ulnaris; two of the fingers, flexor sublimis and profundus, the former flexing the second phalanges, the latter the last, one flexor of the last phalanx of the thumb, flexor longus pollicis. The palmaris longus is primarily a tensor of the palmar fascia, and secondly a flexor of the wrist and forearm. The muscles which arise from the internal condyle of the humerus act as flexors of the elbow-joint, those which pass to the radial side of the hand and arms being more effective in this respect than the muscles on the ulnar side. The superficial and deep flexors of the fingers assist in producing flexion of the wrist, after the flexion of the fingers is completed, or when the fingers are fixed by being pressed against an opposing surface.

Posterior Brachial Region.

Superficial Layer.

Supinator longus,	Extensor minimi digiti,
Extensor carpi radialis longior,	Extensor carpi ulnaris,
Extensor carpi radialis brevior,	Anconeus.
Extensor communis digitorum,	

Dissection.—The integument is to be divided and turned aside, and the fascia removed in the same manner as for the anterior brachial region.

The **SUPINATOR LONGUS** is placed along the radial border of the forearm. It *arises* from the upper two-thirds of the external condylar ridge of the humerus, reaching nearly as high as the insertion of the deltoid, and from the external intermuscular septum passes forward to the anterior aspect of the elbow-joint, and ends in

a long flat tendon, which descends the forearm to be *inserted* into the base of the styloid process of the radius.

Relations.—By its *superficial surface* with the extensor ossis metacarpi pollicis, extensor primi internodii pollicis, and deep fascia of the forearm. By its *deep surface* with the brachialis anticus, extensor carpi radialis longior, tendon of the biceps, supinator brevis, pronator radii teres, flexor carpi radialis, flexor sublimis digitorum, flexor longus pollicis, pronator quadratus, radius, musculo-spiral nerve, radial and posterior interosseous nerve, and radial artery and veins.

FIG. 214. — Superficial layer of muscles of the posterior aspect of the forearm. 1. Biceps. 2. Brachialis anticus. 3. Lower part of the triceps, inserted into the olecranon. 4. Supinator longus. 5. Extensor carpi radialis longior. 6. Extensor carpi radialis brevior. 7. Tendons of insertion of these two muscles. 8. Extensor communis digitorum. 9. Extensor minimi digiti. 10. Extensor carpi ulnaris. 11. Anconeus. 12. Flexor carpi ulnaris. 13. Extensor ossis metacarpi and extensor primi internodii lying together. 14. Extensor secundi internodii; its tendon is seen crossing the tendons of the extensor carpi radialis longior and brevior. 15. Posterior annular ligament. The tendons of the common extensor are seen on the back of the hand, and their mode of distribution on the dorsum of the fingers.

Nerve Supply. — A special branch of the musculo-spiral.

Dissection.—This muscle must be divided through the middle, and the two ends turned aside to expose the next muscle.

The **EXTENSOR CARPI RADIALIS LONGIOR** *arises* from the lower third of the external condylar ridge, immediately below the preceding, and from the intermuscular septum. Its tendon passes through a groove in the radius behind the styloid process, to be *inserted* into the base of the metacarpal bone of the index finger.

Relations. — By its *superficial surface* with the supinator longus, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensor secundi internodii pollicis, radial nerve, fascia of the forearm, and posterior annular ligament. By its *deep surface* with the brachialis anticus, extensor carpi radialis brevior, radius, and wrist-joint.

Nerve Supply.—A special branch of the musculo-spiral.

The **EXTENSOR CARPI RADIALIS BREVIOR** is seen by drawing aside the former muscle. It *arises* from the external condyle of the humerus and intermuscular septa, and is *inserted* into the base of the metacarpal bone of the middle finger. Its tendon is

lodged in the same groove on the radius with that of the extensor carpi radialis longior.

Relations.—By its *superficial surface* with the extensor carpi radialis longior, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensor secundi internodii pollicis, fascia of the forearm, and posterior annular ligament. By its *deep surface* with the supinator brevis, tendon of the pronator radii teres, radius, and wrist-joint. By its *ulnar border* with the extensor communis digitorum.

Nerve Supply.—Posterior interosseous, a branch of the musculo-spiral.

The **EXTENSOR COMMUNIS DIGITORUM** *arises* from the external condyle by a common tendon with the preceding and two following muscles, from the intermuscular septa, and deep fascia; and divides into four tendons, which are *inserted* into the second and third phalanges of the fingers. At the metacarpo-phalangeal articulation each tendon becomes narrow and thick, and sends a thin fasciculus upon each side of the joint. It then spreads out, and receiving the tendon of the lumbricalis and some tendinous fasciculi from the interossei, forms a broad aponeurosis, which covers the whole posterior aspect of the finger. At the first phalangeal joint the aponeurosis divides into three slips. The middle slip is inserted into the base of the second phalanx, and the two lateral portions are continued onwards at each side of the joint, to be inserted into the last. Little oblique tendinous slips connect the tendon of the ring with those of the middle and little finger as they cross the back of the hand.

Relations.—By its *superficial surface* with the deep fascia of the forearm and hand, and posterior annular ligament. By its *deep surface* with the supinator brevis, extensor ossis metacarpi pollicis, extensor primi internodii, extensor secundi internodii, extensor indicis, posterior interosseous artery and nerve, wrist-joint, metacarpal bones, interossei muscles, and phalanges. By its *radial border* with the extensor carpi radialis longior and brevior. By the *ulnar border* with the extensor minimi digiti, and extensor carpi ulnaris.

Nerve Supply.—Posterior interosseous.

The **EXTENSOR MINIMI DIGITI** (auricularis) is an offset from the extensor communis, with which it is connected by means of a tendinous slip. Passing down to the inferior extremity of the ulna, it traverses a distinct fibrous sheath, and at the metacarpo-phalangeal articulation unites with the tendon derived from the common extensor. The common tendon then spreads out into a broad expansion which divides into three slips to be *inserted* as in the other fingers into the last two phalanges. It is to this muscle that the little finger owes its power of separate extension; and, being called into action when the point of the finger is introduced into the meatus of the ear, for the purpose of removing unpleasant sensations or producing titillation, the muscle was called by the old writers "auricularis."

Nerve Supply.—Posterior interosseous.

The **EXTENSOR CARPI ULNARIS** *arises* from the external condyle by the common tendon, from the posterior border of the ulna, and from the deep fascia. Its tendon passes through the posterior groove in the lower extremity of the ulna, to be *inserted* into the base of the metacarpal bone of the little finger.

Relations.—By its *superficial surface* with the deep fascia of the forearm, and posterior annular ligament. By its *deep surface* with the supinator brevis, extensor ossis metacarpi pollicis, extensor secundi internodii, extensor indicis, ulna, and wrist-joint. By its *radial border* it is in relation with the extensor communis digitorum and extensor minimi digiti, and by the *ulnar border* with the anconeus.

Nerve Supply.—Posterior interosseous.

The **ANCONEUS** is a small triangular muscle, having the appearance of being a continuation of the triceps ; it *arises* from the outer condyle and is *inserted* into the olecranon and triangular surface on the outer and back part of the upper extremity of the ulna.

Relations.—By its *superficial surface* with a strong tendinous aponeurosis derived from the triceps. By its *deep surface* with the elbow-joint, orbicular ligament, and slightly with the supinator brevis.

Nerve Supply.—Musculo-spiral.

Deep Layer.

Supinator brevis,
Extensor ossis metacarpi pollicis,
Extensor primi internodii pollicis,
Extensor secundi internodii pollicis,
Extensor indicis.

Dissection. — The muscles of the superficial layer should be removed in order to bring the deep group completely into view.

The **SUPINATOR BREVIS** cannot be seen in its entire extent until the radial extensors of the carpus are divided from their origin. It *arises* from the external condyle, from the external lateral and orbicular ligament, and from a rough depression below the lesser sigmoid notch of the ulna, and winds around the upper part of the radius, to be *inserted* into the neck of that bone and the upper third of the shaft, excepting its internal border, as low down as the insertion of the pronator teres. The posterior interosseous nerve perforates the lower border of this muscle.

Relations.—By its *superficial surface* with the pronator radii teres, supinator longus, extensor carpi radialis longior and brevior, extensor communis digitorum, extensor carpi ulnaris, anconeus, radial artery and veins, musculo-spiral nerve, radial and posterior interosseous nerve. By its *deep surface* with the elbow-joint and ligaments, interosseous membrane, and radius.

Nerve Supply.—Posterior interosseous.

The **EXTENSOR OSSIS METACARPI POLLICIS** is placed immediately below the supinator brevis. It *arises* from the ulna, interosseous membrane, and radius, and is *inserted* into the base of the metacarpal bone of the thumb. Its tendon passes through the groove immediately in front of the styloid process of the radius.

Relations.—By its *superficial surface* with the extensor carpi ulnaris, extensor minimi digiti, extensor communis digitorum, fascia of the forearm, and annular ligament. By its *deep surface* with the ulna, interosseous membrane, radius, tendons of the extensor carpi radialis longior and brevior, and supinator longus, and at the wrist with the radial artery. By its *upper border* with the edge of the supinator brevis; by its *lower border* with the extensor secundi and primi internodii. It is crossed by branches of the posterior interosseous artery and nerve.

Nerve Supply. — Posterior interosseous.

The **EXTENSOR PRIMI INTERNODII POLLICIS**, the smallest of the muscles in this layer, *arises* from the posterior surface of the interosseous membrane and radius, and passes through the groove with the extensor ossis metacarpi, to be *inserted* into the base of the first phalanx of the thumb.

Relations.—The same as the preceding muscle, with the exception of the extensor carpi ulnaris. The muscle accompanies the extensor ossis metacarpi.

Nerve Supply. — Posterior interosseous.

The **EXTENSOR SECUNDI INTERNODII POLLICIS** *arises* from the posterior surface of the ulna and interosseous membrane. Its tendon passes through a separate groove in the radius, and is *inserted* into the base of the last phalanx of the thumb.

Relations.—By its *external surface*, the same as the extensor ossis metacarpi. By its *deep surface* with the ulna, interosseous membrane, radius, wrist-joint, radial artery, and metacarpal bone of the thumb. The

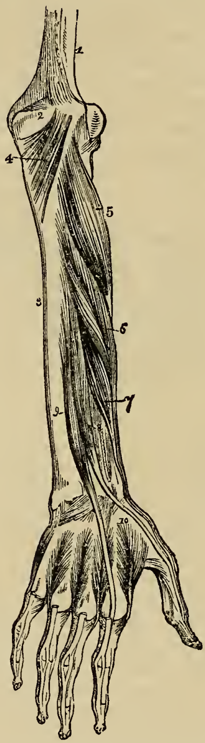


FIG. 215.—Deep layer of muscles of the posterior aspect of the forearm. 1. Humerus. 2. Olecranon. 3. Ulna. 4. Anconeus. 5. Supinator brevis. 6. Extensor ossis metacarpi pollicis. 7. Extensor primi internodii pollicis. 8. Extensor secundi internodii pollicis. 9. Extensor indicis. 10. First dorsal interosseous muscle. The other three dorsal interossei are seen between the metacarpal bones of their respective fingers.

muscle is placed between the extensor primi internodii and extensor indicis.

Nerve Supply.—Posterior interosseous.

The **EXTENSOR INDICIS** (indicator) *arises* from the ulna, below the origin of the extensor secundi internodii, and from the interosseous membrane. Its tendon passes beneath the posterior annular ligament to be *inserted* into the aponeurosis of the common extensor tendon of the index finger.

Relations.—The same as the preceding muscle, with the exception of the hand, where the tendon rests on the metacarpal bone of the forefinger and second interosseous muscle, and has no relation with the radial artery.

Nerve Supply.—Posterior interosseous.

The tendons of the extensors, as of the flexor muscles of the forearm, are provided with synovial bursæ as they pass beneath the annular ligament; those of the back of the wrist have separate sheaths, formed by the posterior annular ligament.

Actions.—The anconeus is associated in its action with the triceps extensor cubiti; it assists in extending the forearm on the arm. The supinator longus is a weak supinator, being effective only in the early part of that action; it is a powerful flexor, but acts only after the flexion has been begun by other muscles. The supinator brevis is the chief supinator, and the direct antagonist of the two pronators. The extensor carpi radialis longior and brevior and extensor carpi ulnaris extend the wrist in opposition to the two flexors of the carpus; they also abduct the hand. The extensor communis digitorum restores the fingers to the straight position after they have been flexed by the two flexors, sublimis and profundus. The extensor ossis metacarpi, primi internodii, and secundi internodii pollicis, are the special extensors of the thumb, and serve to balance the actions of the flexor ossis metacarpi, flexor brevis, and flexor longus pollicis. The extensor indicis produces extension of the index finger, and is therefore named "indicator," and the extensor minimi digiti supplies that finger with the power of exerting a distinct extension.

MUSCLES OF THE HAND.

Radial or Thenar Region.

Abductor pollicis,	Flexor brevis pollicis,
Flexor ossis metacarpi (opponens),	Adductor pollicis.

Dissection.—The hand is best dissected by making an incision along the middle of the palm, from the wrist to the base of the middle finger, and crossing it at each extremity by a transverse incision, then turning aside the flaps of integument. For exposing the muscles of the radial region, the removal of the integument and fascia on the radial side will be sufficient.

The **ABDUCTOR POLLICIS** is a thin flat muscle, which *arises*

from the trapezium bone and annular ligament. It is *inserted* into the radial side of the base of the first phalanx of the thumb.

Nerve Supply.—Median nerve.

Relations.—By its *superficial surface* with the external portion of the palmar fascia; by its *deep surface* with the flexor ossis metacarpi. At its *inner side* it is separated by a narrow cellular interspace from the flexor brevis pollicis. This muscle must be divided from its origin, and turned aside, in order to see the next.

The **FLEXOR OSSIS METACARPI** (opponens pollicis) *arises* from the trapezium and annular ligament, and is *inserted* into the whole length of the metacarpal bone on its radial border.

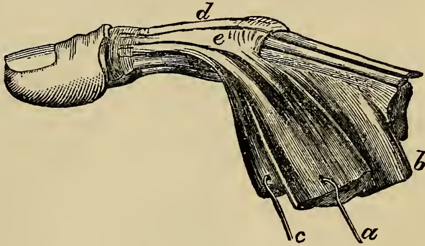


FIG. 216.—Insertion of the muscles of the thumb. *a.* Abductor pollicis. *b.* Opponens pollicis. *c.* Outer head of flexor brevis. *d.* Tendon of extensor secundi internodii. *e.* Tendinous expansion of flexor brevis, joining tendon of extensor.

Nerve Supply. — Median nerve.

Relations.—By its *superficial surface* with the abductor pollicis. By its *deep surface* with the trapezo-metacarpal articulation and metacarpal bone. *Internally* with the flexor brevis pollicis. The flexor ossis metacarpi may now be divided from its origin and turned aside, in order to show the next muscle.

The **FLEXOR BREVIS POLLICIS** consists of two portions, between which lies the tendon of the flexor longus pollicis. The external portion *arises* from the trapezium and annular ligament; the internal portion from the trapezoid, os magnum, and base of the second and third metacarpal bones. They are *inserted* into the two sides of the base of the first phalanx of the thumb, having a sesamoid bone in each of their tendons to protect the joint, and send tendinous slips to join the tendon of the extensor secundi internodii at the back of the first phalanx. The outer head is joined by a considerable bundle of fibres from the inner, which passes behind the long flexor tendon in order to reach it.

Relations.—By its *superficial surface* with the external portion of the palmar fascia. By its *deep surface* with the adductor pollicis, tendon of the flexor carpi radialis, and trapezo-metacarpal articulation. By its *external surface* with the flexor ossis metacarpi and metacarpal bone. By its *inner surface* with the tendons of the long flexor muscles and first lumbricalis.

Nerve Supply.—Outer head by the median nerve, inner by the ulnar.

The **ADDUCTOR POLLICIS** is a triangular muscle; it *arises* by a broad origin from the middle two-thirds of the palmar surface

of the metacarpal bone of the middle finger; the fibres converge to its *insertion* into the base of the first phalanx of the thumb, where it is united with the inner head of the flexor brevis.

Relations.—By its *anterior surface* with the flexor brevis pollicis, tendons of the deep flexor of the fingers, lumbricales, and deep palmar arch. By its *posterior surface* with the metacarpal bones of the index and middle finger, the interossei of the second interosseous space, and the first dorsal interosseous. Its inferior border is subcutaneous.

Nerve Supply.—Ulnar nerve.

Ulnar or Hypothenar Region.

Palmaris brevis,	Flexor brevis minimi digiti,
Abductor minimi digiti,	Flexor ossis metacarpi.

Dissection.—Turn aside the ulnar flap of integument from the palm of the hand; in doing this, a small subcutaneous muscle, the palmaris brevis, will be exposed. After examining this muscle, remove it with the deep fascia, in order to bring into view the muscles of the little finger.

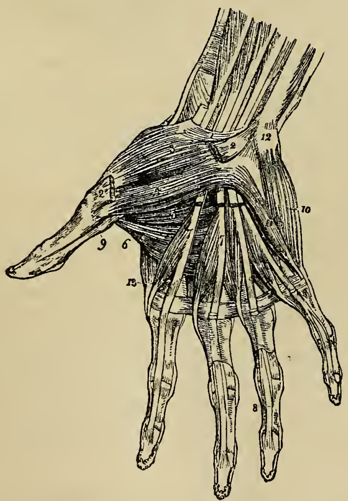


FIG. 217.—Muscles of the hand. 1. Annular ligament. 2, 2. Origin and insertion of the abductor pollicis muscle; the middle portion has been removed. 3. Flexor ossis metacarpi, or opponens pollicis. 4. Superficial portion of the flexor brevis pollicis. 5. Deep portion of the flexor brevis pollicis. 6. Adductor pollicis. 7, 7. The lumbricales muscles, arising from the deep flexor tendons, upon which the figures are placed. The tendons of the flexor sublimis have been removed. 8. One of the tendons of the deep flexor, passing between the two terminal slips of the tendon of the flexor sublimis to reach the last phalanx. 9. The tendon of the flexor longus pollicis, passing between the two portions of the flexor brevis to the last phalanx. 10. Abductor minimi digiti. 11. Flexor brevis minimi digiti. The edge of the flexor ossis metacarpi is seen projecting beyond the inner border of the flexor brevis. 12. Pisiform bone. 13. First dorsal interosseous muscle, the abductor indicis.

The **PALMARIS BREVIS** is a thin plane of muscular fibres about an inch in width, which *arises* from the annular ligament and palmar fascia, and passes transversely inwards to be *inserted* into the integument of the inner border of the hand.

Relations.—By its *superficial surface* with the fat and integument of the inner portion of the palm. By its *deep surface* with the ulnar

portion of the palmar fascia, which separates it from the ulnar artery, veins, and nerve, and from the muscles of the inner border of the hand.

Nerve Supply.—Ulnar nerve.

The **ABDUCTOR MINIMI DIGITI** is a small tapering muscle which *arises* from the pisiform bone, where it is continuous with the tendon of the flexor carpi ulnaris, and is *inserted* into the base of the first phalanx of the little finger, and into the expansion of the extensor tendon.

Relations.—By its *superficial surface* with the internal portion of the deep fascia and palmaris brevis ; by its *deep surface* with the flexor ossis metacarpi and metacarpal bone. By its *inner border* with the flexor brevis minimi digiti.

Nerve Supply.—Ulnar nerve.

The **FLEXOR BREVIS MINIMI DIGITI** is a small muscle *arising* from the unciform bone and annular ligament, and *inserted* into the base of the first phalanx in connection with the preceding muscle. It is sometimes wanting.

Relations.—By its *superficial surface* with the internal portion of the palmar fascia, and palmaris brevis. By its *deep surface* with the flexor ossis metacarpi and metacarpal bone. *Externally* with the abductor minimi digiti, from which it is separated near its origin by the deep palmar branch of the ulnar nerve and communicating artery. *Internally* with the tendons of the flexor sublimis and profundus.

Nerve Supply.—Ulnar nerve.

The **FLEXOR OSSIS METACARPI MINIMI DIGITI** (opponens) *arises* from the unciform bone and annular ligament, and is *inserted* into the whole length of the metacarpal bone of the little finger on its ulnar border. The little finger has also an *adductor*, but it is one of the palmar *interossei*.

Relations.—By its *superficial surface* with the flexor brevis and abductor minimi digiti. By its *deep surface* with the interossei muscles of the last metacarpal space, metacarpal bone, and flexor tendons of the little finger.

Nerve Supply.—Ulnar nerve.

Palmar Region.

Lumbricales, Palmar interossei, Dorsal interossei.

The **LUMBRICALES**, four in number, are accessories to the deep flexor muscle. They *arise* from the tendons of the deep flexor ; the first and second from the radial side of one tendon ; the third and fourth from the contiguous sides of two tendons. They pass to the radial side of each finger and are *inserted* into the aponeurotic expansion of the extensor tendons on the dorsal aspect of the first phalanx. The third, or that of the tendon of the ring finger, sometimes bifurcates, at other times it is inserted wholly into the extensor tendon of the middle finger.

Relations.—In the palm of the hand with the flexor tendons ; at

their insertion, with the tendons of the interossei and the metacarpo-phalangeal articulations.

Nerve Supply.—The two outer by the median, the two inner by the ulnar nerve.

The **PALMAR INTEROSSEI**, three in number, are visible only on the palmar aspect of the hand; they are placed upon the metacarpal bones, rather than between them. They *arise* from the base of the metacarpal bone of one finger, and are *inserted* into the base of the first phalanx and aponeurotic expansion of the extensor tendon of the same finger. The first belongs to the index finger; the second, to the ring finger; the third, to the little finger; the middle finger being omitted.

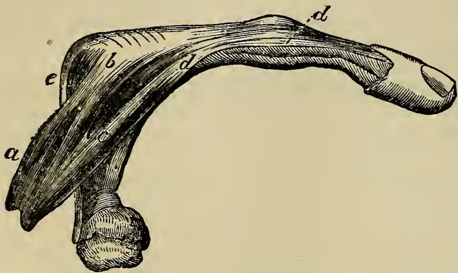


FIG. 218.—Attachment of an interosseous muscle. *a.* Interosseous muscle. *b.* Attachment to the base of first phalanx. *c.* Slip passing forward to *d*, Side of extensor tendon. *e.* Central portion of extensor tendon.

Relations. — By their *palmar surface* with the flexor tendons and deep muscles in the palm of the hand. By their *dorsal surface* with the dorsal interossei. On one side with the metacarpal bone, on the other with the corresponding dorsal interosseous muscle.

DORSAL INTEROSSEI.—Turning to the dorsum of the hand, the four *dorsal interossei* are seen in the four spaces between the metacarpal bones. They are bipenniform muscles, and *arise* by two heads, from adjoining sides of the bases of the metacarpal bones. They are *inserted* into the base of the first phalanges, and into the aponeurosis of the extensor tendons.

The first is inserted into the index finger, and from its use is called abductor indicis; the second and third are inserted into the middle finger, compensating its exclusion from the palmar group; the fourth is attached to the ring finger; so that each finger is provided with two interossei, with the exception of the little finger, as may be shown by means of a table, thus :—

Index finger,	one dorsal (abductor indicis), one palmar.
Middle finger,	two dorsal.
Ring finger,	one dorsal, one palmar.
Little finger,	remaining palmar (adductor minimi digiti).

Relations.—By their *dorsal surface* with a thin aponeurosis, which separates them from the tendons on the dorsum of the hand. By their *palmar surface* with the muscles and tendons in the palm of

the hand. By one side with the metacarpal bone; by the other with the corresponding palmar interosseous. The abductor indicis is in relation by its palmar surface with the adductor pollicis and flexor brevis pollicis. The radial artery passes into the palm of the hand between the two heads of the first dorsal interosseous muscle (abductor indicis); and the perforating branches of the deep palmar arch, between the heads of the other dorsal interossei.

Nerve Supply.—All the interosseous muscles are supplied by the ulnar nerve.

Actions.—The actions of the muscles of the hand are expressed in their names. Those of the radial region belong to the thumb, and provide for three of its movements, *abduction*, *adduction*, and *flexion*. The ulnar group, in like manner, are subservient to the same motions of the little finger, and the interossei are abductors and adductors of the several fingers. The lumbricales are accessory in their actions to the deep flexors; they were called by the earlier anatomists *fidicinii*—*i.e.*, fiddlers' muscles, from an idea that they might effect the rapid movements by which the performer is enabled to produce the various notes on that instrument. The seven interossei and the four lumbricales have a double action on the fingers in consequence of being inserted partly into the bases of the first phalanges and partly into the expansion of the extensor tendon. They thus become flexors of the fingers at the metacarpo-phalangeal joint, and extensors of the two last phalanges; the former action being due to their osseous and the latter to their tendinous insertion.

In relation to the axis of the hand, the four *dorsal* interossei are *abductors*, the three palmar *adductors*. It will therefore be seen that each finger is provided with its proper adductor and abductor, two flexors, and (with the exception of the middle and ring finger) two extensors. The thumb has, moreover, a flexor and extensor of the metacarpal bone; and the little finger a flexor of the metacarpal bone (opponens) without an extensor.

The palmaris brevis draws together the skin on the ulnar margin of the hand, and so increases the hypothenar eminence and deepens the hollow of the hand.

MUSCLES AND FASCIÆ OF THE LOWER EXTREMITY.

The muscles of the lower extremity may be arranged into groups corresponding with the regions of the hip, thigh, leg, and foot, as in the following table:—

Hip.

Gluteal Region.

Gluteus maximus,	Obturator internus,
Gluteus medius,	Gemellus inferior,
Gluteus minimus,	Obturator externus,
Pyriformis,	Quadratus femoris.
Gemellus superior,	

THIGH.

Anterior Femoral Region.

Tensor vaginæ femoris,
Sartorius,
Rectus femoris,
Vastus internus,
Vastus externus,
Crureus.

Internal Femoral Region.

Iliacus internus,
Psoas magnus,
Pectineus,
Adductor longus,
Adductor brevis,
Adductor magnus,
Gracilis.

Posterior Femoral Region.

Biceps femoris, Semi-tendinosus, Semi-membranosus.

LEG.

Anterior Tibial Region.

Tibialis anticus,
Extensor longus digitorum,
Peroneus tertius,
Extensor proprius pollicis.

Fibular Region.

Peroneus longus,
Peroneus brevis.

Posterior Tibial Region.

Superficial group.

Gastrocnemius,
Plantaris,
Soleus.

Deep group.

Popliteus,
Flexor longus pollicis,
Flexor longus digitorum,
Tibialis posticus.

FOOT.

Dorsal Region.

Extensor brevis digitorum,
Dorsal interossei.

Plantar Region.

1*st Layer.*

Abductor pollicis,
Abductor minimi digiti,
Flexor brevis digitorum.

2*d Layer.*

Musculus accessorius,
Lumbricales.

3*d Layer.*

Flexor brevis pollicis,
Adductor pollicis,
Transversus pedis,
Flexor brevis minimi digiti.

4*th Layer.*

Plantar interossei.

FASCIÆ OF THE LOWER EXTREMITY.

The **superficial fascia** of the thigh consists of two layers, the upper or fatty, and the membranous. The first is continuous with

that of the abdomen, and contains more or less fat, according to the subject. Between the two layers are contained the superficial vessels, branches of the femoral artery and vein, also the lymphatics in connection with the absorbent glands of the groin. The deep or membranous layer is thin but strong, and is attached to the fascia lata a short distance below Poupart's ligament by Scarpa's fascia, a thin web proceeding from the deep surface, formerly described (p. 284). It is also closely connected to the fascia lata around the margin of the saphenous opening, which it closes, and here it is more dense than elsewhere, and being pierced by openings for the superficial vessels before alluded to, it is called the *cribriform fascia*, which forms one of the coverings of femoral hernia. It becomes incorporated with the fascia lata as it descends, and at about three inches below the groin becomes inseparably united with it.

The **deep fascia** of the thigh is named, from its great extent, the **fascia lata**; it is thick and strong upon the outer side of the limb, and thinner at its inner and posterior side. That portion of the deep fascia which invests the gluteus maximus is very thin, but that which covers in the gluteus medius is excessively thick, and gives origin, by its inner surface, to the superficial fibres of that muscle. The fascia lata is attached superiorly to Poupart's ligament, the crest of the ilium, sacrum, coccyx, tuberosity of the ischium, ramus of the ischium and pubes, body of the pubes, and pectineal line; it has also a deep attachment (ligamentum iliacum) to the anterior border of the ilium, tendon of origin of the rectus muscle, and border of the acetabulum. It forms sheaths for the muscles of the thigh and femoral vessels, and is connected with the linea aspera by means of two *intermuscular septa*, *external* and *internal*; the former extending from the insertion of the gluteus maximus to the external condyle, and separating the vastus externus from the biceps muscle; the internal being attached to the inner branch of the linea aspera for a short distance above the internal condyle, and separating the vastus internus from the adductor magnus. The fascia lata receives the attachment of two muscles, tensor vaginæ femoris and gluteus maximus, and glides over the trochanter major on a bursa. At the lower part of the thigh, the fascia forms a very distinct band of about an inch and a half in width, **ilio-tibial band**, which receives tendinous fibres from the extensor and flexor muscles of the thigh, and is inserted into the outer tuberosity of the tibia and head of the fibula. At the back of the knee the fascia bridges over the popliteal space, the longitudinal fibres being strengthened by numerous transverse fasciculi.

In addition to the smaller openings in the fascia lata which transmit the small cutaneous vessels and nerves, there exists at the upper and inner extremity of the thigh an oval opening which gives passage to the superficial lymphatic vessels, and the large subcutaneous vein of the lower extremity, the internal saphenous vein, and is thence named the **saphenous opening**. The existence of this open-

ing has given rise to the division of the upper part of the fascia lata into two portions, an iliac portion and a pubic portion.

The **iliac portion** is situated upon the iliac side of the opening. It is attached to the crest of the ilium, and along Poupart's ligament to the spine of the pubes, whence it is reflected downwards and outwards in an arched direction, and forms a *falciform* border, which constitutes the outer boundary of the saphenous opening. The edge of this border immediately overlies, and is adherent to, the sheath of the femoral vessels, and the lower extremity of the curve is continuous with the pubic portion.

The **pubic portion**, occupying the pubic side of the saphenous opening, is attached to the spine of the pubes and pectineal line; and passing outwards behind the sheath of the femoral vessels, divides into two layers; the anterior layer is continuous with that portion of the iliac fascia which forms the sheath of the iliacus and psoas muscle, the posterior layer is lost upon the capsule of the hip-joint.

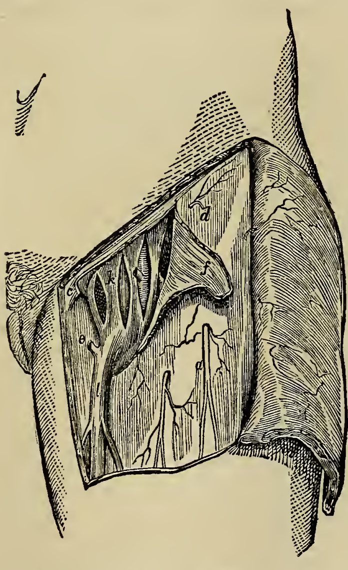


FIG. 219.—Crural sheath laid open. *a.* Middle cutaneous nerve. *c.* Placed to the inner side of Gimbernat's ligament. *d.* Iliac portion of fascia lata. *e.* Pubic portion of fascia lata. *f.* Margin of saphenous opening (turned back). *k.* Femoral sheath opened by three incisions. *l.* Saphena vein.

The interval between the falciform border of the iliac portion and the opposite surface of the pubic portion is closed by an areolo-fibrous layer, derived from the superficial fascia, and pierced by numerous openings for the passage of lymphatic vessels, the **cribriform fascia.** The cribriform fascia is connected with the sheath of the femoral vessels, and forms one of the coverings of femoral hernia. When the iliac portion of the fascia lata is removed from its attachment to Poupart's ligament and turned aside, the sheath of the femoral vessels (the **femoral** or **crural canal**) is brought into view; and if Poupart's ligament be carefully divided, the sheath may be isolated, and its continuation with the transversalis and iliac fascia demonstrated. In this view, the sheath of the femoral vessels is an infundibuliform continuation of the abdominal fascia, closely adherent to the vessels a little way down the thigh, but much larger than the vessels it contains at Poupart's ligament. If the sheath be opened, the artery

and vein will be found lying side by side, and occupying the outer two-thirds of the sheath, leaving an infundibuliform interval between the vein and inner wall of the sheath; this portion of the sheath is sometimes distinguished under a different title and called **crural sheath.** The superior opening of the space is named the **femoral** or **crural ring**; it is bounded in front by Poupart's ligament, behind by the os pubis, internally by Gimbernat's ligament, and externally by the femoral vein. The interval itself serves for the passage of the superficial lymphatic vessels from the saphenous opening to a lymphatic gland, which generally occupies the femoral ring, and from thence they proceed into the current of the deep lymphatics. The femoral ring is closed merely by a thin layer of sub-serous

Fig. 220.—Section of the structures which pass beneath the crural arch. 1. Poupart's ligament. 2, 2. Iliac portion of the fascia lata, attached along the margin of the crest of the ilium, and along Poupart's ligament, as far as the spine of the pubes (3). 4. Pubic portion of the fascia lata, continuous at 3 with the iliac portion, and passing outwards behind the sheath of the femoral vessels to its outer border at 5, where it divides into two layers; one is continuous with the sheath of the psoas (6), and iliacus (7); the other (8) is lost upon the capsule of the hip-joint (9). 10. The anterior crural nerve. 11. Gimbernat's ligament. 12. The femoral ring, within the femoral sheath. 13. Femoral vein. 14. Femoral artery; the two vessels and the ring are surrounded by the femoral sheath, and thin septa are sent between the anterior and posterior wall of the sheath, dividing the artery from the vein, and the vein from the femoral ring.

areolar tissue, which retains the lymphatic gland in its position, and is named **septum crurale**, and by the peritoneum. It follows from this description that the femoral ring must be a weak point in the parietes of the abdomen, particularly in the female, in whom the **femoral arch**, or space included between Poupart's ligament and the border of the pelvis, is larger than in the male, while the structures which pass through it are smaller. It happens, consequently, that if violent or continued pressure be made upon the abdominal viscera, a portion of intestine may be forced through the femoral ring into the infundibuliform space in the sheath of the femoral vessels, carrying before it the peritoneum and septum crurale,—this constitutes **femoral hernia.** If the causes which gave rise to the formation of the hernia continue, the intestine, unable to extend further down the sheath, from the close connection of the latter with

the vessels, will, in the next place, be forced forwards through the saphenous opening in the fascia lata, carrying before it two additional coverings, the sheath of the vessels or fascia propria, and the cribriform fascia; and then, curving upwards over Poupart's ligament, the hernia will become placed beneath the superficial fascia and integument.

The direction which femoral hernia takes in its descent is at first *downwards*, then *forwards*, and then *upwards*; and in endeavouring to reduce it, the application of the taxis must have reference to this course, and be directed in precisely the reverse order. The coverings of femoral hernia are the—

Integument,	Femoral sheath,
Superficial fascia,	Septum crurale,
Cribriform fascia,	Peritoneal sac.

The **deep fascia of the leg** is attached to the inner and outer tuberosity of the tibia and head of the fibula, and receives an accession of fibres from the tendons of the sartorius, gracilis, and biceps. Between its points of attachment, and especially behind, it is continuous with the fascia of the thigh. In the front of the leg it encloses the tibialis anticus and extensor muscles, and affords origin to some of their fibres. On the outer side it forms a sheath for the peronei muscles; and behind, two sheaths, superficial and deep; the former for the gastrocnemius and soleus with the tendo-Achillis, the latter for the deep flexor muscles. At the ankle these four sheaths are differently arranged; the posterior superficial sheath terminates on the os calcis with the tendo-Achillis; the posterior deep sheath is attached at one side to the border of the internal malleolus, at the other to the os calcis and inner side of the foot, being blended with the origin of the abductor pollicis. This portion of the deep fascia is the **internal annular ligament**; it sends processes inwards to divide the tendons of the flexors and form sheaths for their passage into the foot. The sheath of the peronei muscles at the outer ankle is attached to the external malleolus on one side, and the border of the os calcis on the other, and forms the **external annular ligament**. The anterior portion of the fascia forms at the ankle the **anterior annular ligament**; it is divisible into two parts, the upper being transversely disposed, the lower arranged in the form of the letter ⋈ placed on its side. The latter is often described as a separate ligament under the name of *cruciform ligament*; it is composed of two bands about half-an-inch in width, blended with each other at their point of union on the front of the joint. The internal band is attached above to the internal malleolus and below to the os calcis at the outer side of the foot; the external band to the external malleolus above, and the scaphoid and internal cuneiform bone at the inner border of the foot. The internal band at its origin consists of two layers, between which passes the tendon of the tibialis anticus. The tendons of the extensor longus digitorum and peroneus tertius have also a separate loop connected with the cruci-

form ligament, the *sling ligament* of Retzius; this is a narrow band which embraces the tendons in a sling-shaped loop, and passes outwards and backwards to be attached to the sulcus tali and neighbouring part of the calcaneum. The tendons passing through the loops and sheaths around the ankle are each furnished with a synovial bursa. That portion of the deep fascia of the leg which forms a septum between the superficial and deep muscles of the back of the leg is sometimes called the *intermuscular fascia;* and in operations on the arteries of that region the *deep layer* of the deep fascia. There is besides another deep portion of fascia above the preceding, the **popliteal fascia**, derived from the tendon of the semi-membranosus muscle and binding down the popliteus muscle. By its inferior border this fascia is inserted into the popliteal line of the tibia.

The **fasciæ dorsales pedis** are three in number, superficial, middle, and deep.

The *superficial layer* of deep fascia of the foot is thin and covers the dorsum of the foot, being continuous at the ankle with the cruciform ligament, and attached at either side to the borders of the foot, where it becomes united with the plantar fascia. A second or *middle layer* of fascia covers in the anterior part of the extensor brevis digitorum with its tendons; and a third or *deep layer* is found beneath the latter, and covering in the interossei muscles. On the interossei muscles the three layers are united, and the extensor tendons are consequently separated from each other in their course to the toes.

The Plantar Fascia consists of three portions, middle and two lateral.

The *middle portion* is thick and dense, and composed of strong aponeurotic fibres, closely interwoven with each other. It is attached posteriorly to the inferior surface of the tuberosities of the os calcis, and terminates under the heads of the metatarsal bones in five fasciculi. Each of these fasciculi bifurcates to embrace the base of the corresponding toe, and is attached in the middle to the sheath of the flexor tendons, and at either side to the head of the metatarsal bone. The point of division of the fascia into fasciculi is strengthened by transverse bands, which preserve the solidity of the fascia at its broadest part. The intervals between the toes give passage to the digital arteries and nerves and lumbricales muscles.

The *lateral portions* are thin, and cover the sides of the sole of the foot; they are continuous behind with the internal and external annular ligament; and on the mesial side with the central portion. The *inner* portion is continuous along the border of the foot with the fascia of the dorsum; the *outer* portion is attached to the os calcis and base of the metatarsal bone of the little toe, forming between these points a thick band, which gives origin to part of the abductor minimi digiti muscle.

Besides constituting a strong layer of investment and defence to the soft parts situated in the sole of the foot, these three portions of fascia send processes inwards, which form sheaths for the different

muscles. A strong septum (intermuscular septum) is given off from each side of the middle portion of the plantar fascia, which is attached to the tarsal bones, and divides the muscles into three groups, middle and two lateral; and transverse septa are stretched between these to separate the layers. The superficial layer of muscles derive part of their origin from the plantar fascia.

Gluteal Region.

Dissection.—The subject being turned on its face, and a block placed beneath the pubes to support the pelvis, the student commences the dissection of this region by carrying an incision from the apex of the coccyx along the crest of the ilium to its anterior superior spinous process; or *vice versâ*, if he be on the left side. He then reflects the integument, superficial fascia, and deep fascia, which latter is very thin over this muscle, from the gluteus maximus following rigidly the course of its fibres; and having exposed the muscle in its entire extent, he dissects the integument and superficial fascia from off the deep fascia which binds down the gluteus medius, the other portion of the region.

Gluteus maximus,	Gemellus superior,
Gluteus medius,	Obturator internus,
Gluteus minimus,	Gemellus inferior,
Pyriformis,	Obturator externus,

Quadratus femoris.

The **GLUTEUS MAXIMUS** (γλουτὸς, nates) is the thick, fleshy mass of muscle, of a trapezoid shape, which forms the convexity of the nates. In structure it is coarse, being made up of fibres collected into large fasciculi, and these again into distinct muscular masses, separated by deep furrows. It *arises* from the posterior fifth of the crest and external surface of the ilium, from the posterior surface of the sacrum and coccyx, and from the great sacro-ischiatic ligament. It passes obliquely outwards and downwards, to be *inserted* into the rough line leading from the trochanter major to the linea aspera, and is continuous by means of its tendon with the fascia lata covering the outer side of the thigh, and with the ilio-tibial band. Several bursæ are situated between this muscle and subjacent parts: one upon the tuberosity of the ischium, one between its tendon and the trochanter major, and one between it and the tendon of the vastus externus.

Relations.—By its *superficial surface* with a thin aponeurotic fascia, which separates it from the superficial fascia and integument, and near its insertion, with the vastus externus. By its *deep surface* with the gluteus medius, pyriformis, gemelli, obturator internus, quadratus femoris, sacro-ischiatic foramina, great sacro-ischiatic ligament, tuberosity of the ischium, semi-membranosus, semi-tendinosus, biceps, and adductor magnus; gluteal vessels and nerve, ischiatic vessels and nerves, and internal pudic vessels and nerve.

By its *upper border* it overlaps the gluteus medius; and by the *lower border* forms the lower margin of the nates. The gluteus maximus must be turned down from its origin, in order to bring the next muscles into view.

Nerve Supply.—Inferior gluteal branch of the lesser ischiatic nerve.

The **GLUTEUS MEDIUS** is placed in front of, rather than beneath, the gluteus maximus; and is covered in by a process of the deep fascia, which is very thick and dense. It *arises* from the outer lip of the crest of the ilium for four-fifths its length, from the surface of bone between the superior and middle curved lines of the dorsum ilii, and from the thick fascia above mentioned. Its fibres converge to the outer part of the trochanter major, into which its tendon is *inserted.*

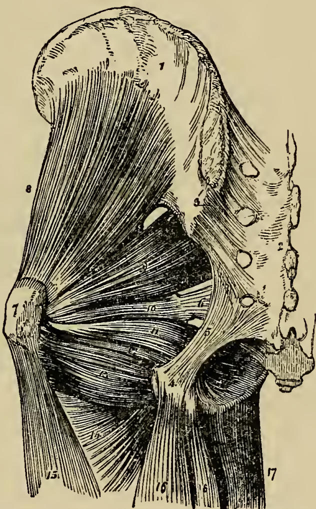


FIG. 221.—Deep muscles of the gluteal region. 1. Ilium. 2. Sacrum. 3. Posterior sacro-iliac ligaments. 4. Tuberosity of the ischium. 5. Great or posterior sacro-ischiatic ligament. 6. Lesser or anterior sacro-ischiatic ligament. 7. Trochanter major. 8. Gluteus minimus. 9. Pyriformis. 10. Gemellus superior. 11. Obturator internus, passing out of the lesser sacro-ischiatic foramen. 12. Gemellus inferior. 13. Quadratus femoris. 14. Adductor magnus. 15. Vastus externus. 16. Biceps. 17. Gracilis. 18. Semi-tendinosus.

Relations.—By its *superficial surface* with the tensor vaginæ femoris, gluteus maximus, and its own proper fascia. By its *deep surface* with the gluteus minimus and gluteal vessels and nerve. By its *lower border* with the pyriformis muscle. A bursa is interposed between its tendon and the upper part of the trochanter major.

Nerve Supply.—Superior gluteal nerve, from the sacral plexus.

This muscle should now be removed from its origin and turned down, to expose the next, which is situated beneath it.

The **GLUTEUS MINIMUS** is a radiate muscle *arising* from the surface of the dorsum ilii, between the middle and inferior curved lines; its fibres converge to the anterior border of the trochanter major, into which it is *inserted* by means of a rounded tendon. There is no distinct separation between the gluteus medius and minimus anteriorly.

Relations.—By its *superficial surface* with the gluteus medius and gluteal vessels. By its *deep surface* with the ilium, long tendon of the rectus femoris, and capsule of the hip-joint. A bursa is interposed between its tendon and the trochanter.

Nerve Supply.—Superior gluteal nerve.

The **PYRIFORMIS** (*pyrum*, a pear), *i.e.*, pear-shaped, *arises* from the anterior surface of the sacrum, by three little slips interposed between the anterior sacral foramina, from the first to the fourth, from the adjoining surface of the ilium, and from the greater sacro-ischiatic ligament. It passes out of the pelvis through the great sacro-ischiatic foramen, and is *inserted* by a rounded tendon into the posterior border of the trochanter major.

Relations.—By its *superficial* or *external surface* with the sacrum and gluteus maximus. By its *deep* or *pelvic surface* with the rectum, sacral plexus of nerves, branches of the internal iliac artery, great sacro-ischiatic notch, and capsule of the hip-joint. By its *upper border* with the gluteus medius and gluteal vessels and nerve. By its *lower border* with the gemellus superior, ischiatic vessels and nerves, and internal pudic vessels and nerve.

Nerve Supply.—A branch from the sacral plexus.

The **GEMELLUS SUPERIOR** (*gemellus*, double, twin) is a small slip of muscle situated immediately below the pyriformis; it *arises* from the spine of the ischium, and is *inserted* into the upper border of the tendon of the obturator internus, and into the upper border of the trochanter major. The gemellus superior is not unfrequently wanting.

Relations.—By its *superficial surface* with the gluteus maximus, ischiatic vessels and nerves, and internal pudic vessels and nerve. By its *deep surface* with the pelvis and capsule of the hip-joint.

Nerve Supply.—A branch from the sacral plexus.

The **OBTURATOR INTERNUS** *arises* from the inner surface of the anterior wall of the pelvis, being attached to the margin of bone around the obturator foramen and to the obturator membrane. It passes out of the pelvis through the lesser sacro-ischiatic foramen, and is *inserted* by a flattened tendon into the inner aspect of the upper border of the trochanter major. The lesser sacro-ischiatic notch, over which this muscle plays as through a pulley, is faced with cartilage, and provided with a synovial bursa to facilitate its movements. The tendon of the obturator is bordered above and below by the gemelli muscles (hence their names), which are inserted into the sides of its tendon, and appear to be auxiliaries or superadded portions—external origins, in fact, of the obturator internus.

Relations.—By its *superficial* or *posterior surface* with the internal pudic vessels and nerve, the obturator fascia, which separates it from the levator ani and viscera of the pelvis, the sacro-ischiatic ligaments, gluteus maximus, and ischiatic vessels and nerves. By its *deep* or *anterior surface* with the obturator membrane and the margin of bone surrounding it, the cartilaginous pulley of the lesser ischiatic foramen, external surface of the pelvis, and capsular ligament of the hip-joint. By its *upper border* within the pelvis, with the obturator vessels and nerve; externally to the pelvis, with the gemellus superior. By its *lower border* with the gemellus inferior.

Nerve Supply.—A special branch of the sacral plexus.

The **GEMELLUS INFERIOR** *arises* from the posterior border of the tuberosity of the ischium, and is *inserted* into the lower border of the tendon of the obturator internus, and into the upper border of the trochanter major.

Relations.—By its *superficial surface* with the gluteus maximus, and ischiatic vessels and nerves. By its *deep surface* with the external surface of the pelvis and capsule of the hip-joint. By its *upper border* with the tendon of the obturator internus. By its *lower border* with the tendon of the obturator externus and quadratus femoris.

Nerve Supply.—A branch from the sacral plexus.

In this region only the tendon of the obturator externus can be seen; it is situated deeply between the gemellus inferior and upper border of the quadratus femoris. To expose the muscle fully, it is necessary to dissect it on the anterior part of the thigh, after the removal of the pectineus, adductor longus, and adductor brevis.

The **OBTURATOR EXTERNUS** muscle (*obturare*, to stop up) *arises* from the obturator membrane and from the surface of the bone immediately surrounding it anteriorly—viz., from the ramus of the pubes and ischium; its tendon passes outwards behind the neck of the femur, to be *inserted* into the digital fossa of the trochanter major. When the femur is rotated outwards the tendon of this muscle lies in the groove between the acetabulum and tuberosity of the ischium.

Relations.—By its *superficial* or *anterior surface* with the tendon of the psoas and iliacus, pectineus, adductor brevis and magnus, obturator vessels and nerve. By its *deep* or *posterior surface* with the obturator membrane and margin of bone which surrounds it, the lower part of the capsule of the hip-joint and quadratus femoris.

Nerve Supply.—The obturator nerve.

The **QUADRATUS FEMORIS** (square-shaped) *arises* from the external border of the tuberosity of the ischium; and is *inserted* into a rough line on the posterior border of the trochanter major, which is thence named linea quadrati.

Relations.—By its *posterior surface* with the gluteus maximus, and ischiatic vessels and nerves. By its *anterior surface* with the tendon of the obturator externus and trochanter minor, a synovial bursa often separating it from the latter. By its *upper border* with the gemellus inferior; and by the *lower border* with the adductor magnus.

Nerve Supply.—A branch from the sacral plexus.

Actions.—The glutei muscles are abductors of the thigh, when they take their fixed point from the pelvis. Taking their fixed point from the thigh, they steady the pelvis on the head of the femur; this action is peculiarly obvious in standing on one leg: they assist also in carrying the leg forward in progression. The gluteus minimus being attached to the anterior border of the trochanter major, rotates the limb slightly inwards. The gluteus medius and maximus, from their insertion into the posterior aspect of the bone,

rotate the limb outwards; the latter is, moreover, a tensor of the fascia of the thigh, and through the agency of the ilio-tibial band acts as an extensor of the leg on the thigh. The other muscles rotate the limb outwards, everting the knee and foot; hence they are named external rotators.

The obturator externus, besides being an external rotator, is also a flexor and adductor of the thigh.

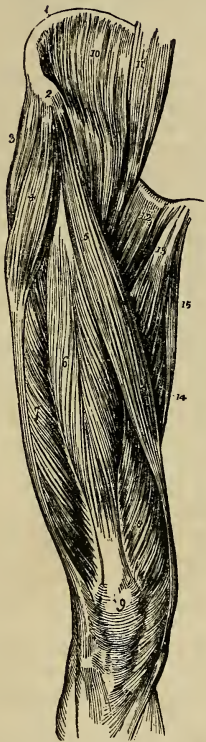


Fig. 222.—Muscles of the anterior femoral region. 1. Crest of the ilium. 2. Its anterior superior spinous process. 3. Gluteus medius. 4. Tensor vaginæ femoris; its insertion into the fascia lata is shown inferiorly. 5. Sartorius. 6. Rectus. 7. Vastus externus. 8. Vastus internus. 9. Patella. 10. Iliacus internus. 11. Psoas magnus. 12. Pectineus. 13. Adductor longus. 14. Part of the adductor magnus. 15. Gracilis.

Anterior Femoral Region.

Tensor vaginæ femoris,	Vastus internus,
Sartorius,	Vastus externus,
Rectus femoris,	Crureus.

Dissection.—Make an incision along the line of Poupart's ligament, from the anterior superior spinous process of the ilium to the spine of the pubes; and a second, from the inner end of the preceding, down the inner side of the thigh, and across the inner condyle of the femur to about two inches below the head of the tibia, where it may be bounded by a transverse incision. Turn back the integument from the whole of this region, and examine the superficial fascia; which is next to be removed in the same manner. After the deep fascia has been well considered, it is likewise to be removed, by dissecting it off in the course of the fibres of the muscles. As it might not be convenient to the junior student to expose so large a surface at once as ordered in this dissection, the vertical incision may be crossed by one or two transverse incisions, as may be deemed most proper.

The **TENSOR VAGINÆ FEMORIS** (stretcher of the sheath of the thigh) is a short flat muscle, situated on the outer side of the hip. It *arises* from the crest of the ilium, near its anterior superior spinous process, and from the notch between the two anterior spinous processes, and is *inserted* between two layers of the fascia lata at about one-fourth down the thigh.

Relations.—By its *superficial surface* with the fascia lata and integument. By its *deep surface* with an internal layer of the fascia

lata, gluteus medius, rectus, and vastus externus. By its *inner border* near its origin with the sartorius.

Nerve Supply.—Superior gluteal nerve.

The **SARTORIUS** (tailor's muscle) is a long ribbon-like muscle, *arising* from the anterior superior spinous process of the ilium, and from the notch immediately below that process; it crosses obliquely the upper third of the thigh, descends behind the inner condyle of the femur, and is *inserted* by an aponeurotic expansion into the upper part of the inner side of the tibia, nearly as far forward as the crest. This expansion covers in the insertion of the tendons of the gracilis and semi-tendinosus muscles. The inner border of the sartorius muscle is the guide to the operation for tying the femoral artery in the middle of its course; and the outer boundary of Scarpa's triangular space.

Nerve Supply.—Anterior crural nerve.

Relations.—By its *superficial surface* with the fascia lata and cutaneous nerves. By its *deep surface* with the psoas and iliacus, rectus, sheath of the femoral vessels, vastus internus, adductor longus, adductor magnus, gracilis, long saphenous nerve, internal lateral ligament of the knee-joint. By its expanded insertion with the tendons of the gracilis and semi-tendinosus, a synovial bursa being interposed. At the knee-joint its *posterior border* is in relation with the internal saphena vein.

SCARPA'S SPACE.—This is a triangular space of some surgical importance situated at the upper part of the thigh; in its upper part femoral hernia takes place, and in its lower part ligature of the femoral artery is usually performed. Its base is formed by Poupart's ligament, its inner border by the adductor longus, its outer border by the sartorius muscle, and its apex is at the point where the latter muscle crosses the artery. Its floor is formed by the iliacus, psoas, pectineus, adductor longus, and a small part of the adductor brevis. A perpendicular line, drawn from the middle of the base to the apex of this triangle, immediately overlies the femoral artery with its sheath.

The **RECTUS FEMORIS** is a fusiform muscle placed in the middle of the anterior aspect of the thigh. It *arises* by a flattened tendon from the space between the inferior curved line of the dorsum of the ilium and the upper margin of the acetabulum, its fibres being intimately blended with the circular fibres of the capsular ligament of the hip, and with the cotyloid ligament; this is usually described as the *reflected* head. The muscle is also connected by means of a rounded accessory band of condensed areolar tissue with the anterior inferior spine of the ilium, and by a falciform process to about an inch of the anterior border of the ilium above the inferior spine; this connection is generally regarded as the direct continuation of the muscle, and is described as the *straight* head. These heads are connected by a deep process of the ilio-tibial band and by areolar and adipose tissue situated between the two layers of that process of fascia. The body of the muscle is spindle-shaped, and

is composed of fleshy and tendinous fibres disposed in the following manner: the superior tendon as it descends spreads out into an aponeurosis which covers the anterior surface of the upper third of the muscle, and sends a tendinous band between the fleshy fibres as far as the lower third of the thigh; the inferior tendon, in like manner, spreads out on the back part of the muscle, so as to form an aponeurosis which covers the lower two-thirds of that aspect. Between these two the fleshy fibres pass, being arranged in a penniform manner, those in the middle of the thigh being connected anteriorly with the tendinous band above described as originating from the upper aponeurosis. The lower tendon becomes narrowed a few inches above the patella into a flat band which receives on its borders the attachment of some fibres of the vastus externus and internus, and is *inserted* into the anterior edge of the upper surface of the patella.

Relations.—By its *superficial surface* with the gluteus medius, psoas and iliacus, sartorius; and for the lower three-fourths of its extent with the fascia lata. By its *deep surface* with the capsule of the hip-joint, external circumflex vessels, crureus, vastus internus and externus.

Nerve Supply.—Anterior crural nerve.

The rectus must now be divided through its middle, and the two ends turned aside to bring clearly into view the next muscles.

The **VASTUS EXTERNUS** *arises* from the upper end of the spiral line of the femur as far inwards as the external cervical tubercle, from the inferior border of the great trochanter (where that process joins the shaft of the bone), from the line leading from the great trochanter to the linea aspera, from the outer lip of the latter as far down as its bifurcation, and from the external intermuscular septum. At the point of its attachment where it lies against the insertion of the gluteus maximus, it becomes blended with the tendon of that muscle, and where the two muscles glide over each other a bursa is interposed. The greater part of the superficial surface is aponeurotic, this being usually the case with the upper three-fourths, excepting the anterior border; the fleshy fibres run downwards and slightly forwards, passing from the superficial aponeurosis to one situated on the deep aspect of the muscle and derived from the tendon of insertion. The lower fleshy fibres are more oblique than the upper; they are inserted into a narrow thick tendon which is intimately connected with the crureus and rectus; from this tendon fibrous expansions are given off, which, blending with similar processes derived from the other extensor muscles, form a fibrous capsule which passes over the lateral aspect of the front of the knee-joint, and is inserted into the head of the tibia. The tendon of insertion gives off an aponeurosis which lines the deep surface of the muscle for the lower half of its extent; traced downwards the tendon is found to be *inserted* into the upper half of the outer border of the patella.

It is often difficult to define the anterior edge of this muscle, and

to distinguish its fibres from those of the crureus, but the line of separation is almost invariably indicated by the course of the external circumflex vessels, and the nerve passing to the muscle itself.

Relations.—By its *superficial surface* with the fascia lata, rectus, biceps, semi-membranosus, and gluteus maximus. By its *deep surface* with the crureus and femur.

Nerve Supply.—Anterior crural nerve.

The **VASTUS INTERNUS** *arises* from the spiral line of the femur, from the internal cervical tubercle to the point where that line joins the linea aspera, and from the inner border of the latter as far as the groove for the femoral artery. As was observed with the vastus externus, the superficial portion of the muscle is chiefly aponeurotic, excepting at the lower third of the thigh, where it becomes fleshy. The fleshy fibres below the groove for the artery spring from the rounded tendon of insertion of the adductor magnus and the fibrous membrane which unites that tendon with the internal supracondylar line. The fibres of the vastus externus are connected at their origin with those of the adductor muscles; they lie upon and clothe the inner surface of the femur, but are not attached to it. The muscle is *inserted* by a tendon common to it, the crureus, vastus externus and rectus, into the front of the inner half of the base of the patella, but the lower fibres pass directly to the inner border of that bone without joining the tendon, and from this latter portion of the muscle an aponeurosis is prolonged to be inserted immediately below the inner tuberosity of the tibia, some of its fibres joining the internal lateral ligament of the knee. In its upper part the muscle is often blended with the crureus, but their line of separation may be made out by following the course of a small nerve which is derived from the upper branch to the vastus internus, and passes down between the vastus internus and crureus to be distributed to the subcrureus and upper part of the synovial pouch of the knee.

Relations.—By its *superficial surface* with the psoas and iliacus, rectus, sartorius, femoral artery and vein, and saphenous nerve, pectineus, adductor longus, brevis, and magnus, and fascia lata. By its *deep surface* with the crureus and femur.

Nerve Supply.—Anterior crural nerve.

The **CRUREUS** (*crus*, the leg) consists of four laminæ placed one over the other; separated above, at their origin, by intervals of bare bone, but fused below. The first of these is placed superficially to the rest, and *arises* from the spiral line to the outer side of the internal cervical tubercle; its attachment passes from thence down the outer surface of the bone to the gluteal ridge, and is continued downwards along the outer lip of the linea aspera and external intermuscular septum. Below the point where the linea aspera divides, the fibres cease to arise from bone, but continue to spring from the external intermuscular septum close to its attachment to the supracondylar line. The second layer lies beneath the first, and is attached lower down on the shaft of the femur, and the

third and fourth in like manner lie beneath and below the second. Each layer arises entirely by fleshy fibres in the form of an arched process, which extends from the inner border of the shaft transversely across its front, and then obliquely down its outer surface for a short distance to the linea aspera, where it blends with the adjacent layers of the crureus, the vastus externus and external intermuscular septum. The lower two-thirds of the anterior surface of the crureus is aponeurotic, the aponeurosis being narrow below, where it lies in the middle of the limb, and spreads out above, where it covers the whole of the anterior and part of the outer surface. The crureus is *inserted* by means of the common tendon into the upper surface of the patella.*

Relations.—By its *superficial surface* with the external circumflex vessels, rectus, vastus internus and externus. By its *deep surface* with the femur, sub-crureus, and synovial membrane of the knee-joint.

Nerve Supply.—Anterior crural nerve.

The four muscles above described are often grouped under one common title as the **quadriceps extensor cruris**; or, the three muscles most intimately connected, the two vasti and the crureus, receive the name of **triceps femoralis.**

SUB-CRUREUS.—When the crureus is divided from its insertion, a small muscle is seen upon the lower part of the femur; it generally consists of two fasciculi, external and internal, which are inserted into the pouch of synovial membrane that extends upwards from the knee-joint, behind the patella; and is named, from its situation, *sub-crureus*. It would seem to be intended to support the synovial membrane.

Actions.—The tensor vaginæ femoris renders the fascia lata tense, and slightly inverts the limb. The sartorius flexes the leg upon the thigh, and, continuing to act, the thigh upon the pelvis, at the same time carrying the leg across that of the opposite side, into the position in which tailors sit; hence its name. Taking its fixed point from below, it assists the extensor muscles in steadying the leg, for the support of the trunk. The other four muscles have been collectively named *quadriceps extensor*, from their similarity of action. They extend the leg upon the thigh, and obtain a great increase of power by their attachment to the patella, which acts as a fulcrum. Taking their fixed point from the tibia, they steady the femur upon the leg, and the rectus, being attached to the pelvis, serves to balance the trunk upon the lower extremity.

Internal Femoral Region.

Iliacus internus,	Adductor longus,
Psoas magnus,	Adductor brevis,
Pectineus,	Adductor magnus,
	Gracilis.

* The above description of the extensor muscles is condensed from an exhaustive account given by Mr. W. Roger Williams, M.R.C.S., in the *Journal of Anatomy and Physiology*, vol. xiii. p. 204.

Dissection.—These muscles are exposed by the removal of the inner flap of integument recommended in the dissection of the anterior femoral region. The iliacus and psoas arising from within the abdomen can only be seen in their entire extent after the removal of the viscera from that cavity.

The **ILIACUS INTERNUS** is a flat radiated muscle. It *arises* from the fossa of the ilium, ilio-lumbar ligament, base of the sacrum, internal lip of the crest, and anterior border of the bone; and after escaping beneath the crural arch and joining the tendon of the psoas, is *inserted* into the trochanter minor of the femur. A few fibres of this muscle are derived from the base of the sacrum, and others from the capsular ligament of the hip-joint.

Theile, with several other anatomists, regards the iliacus internus and psoas magnus as a single muscle arising by two heads: the iliacus has no proper tendon, its muscular fibres being inserted into that of the psoas. He describes the combined muscle under the name of *flexor femoris.*

Relations.—By its *anterior surface*, within the pelvis, with the external cutaneous nerve and iliac fascia, which latter separates it from the peritoneum, on the right from the cæcum, and on the left from the sigmoid flexure of the colon; *externally* to the pelvis, with the fascia lata, rectus, and sartorius. By its *posterior surface* with the iliac fossa, margin of the pelvis, and capsule of the hip-joint, a synovial bursa of large size being interposed. This bursa sometimes communicates with the synovial membrane of the ilio-femoral articulation. By its *inner border*, with the psoas magnus and crural nerve.

Nerve Supply.—Anterior crural nerve.

The Iliac Fascia (lumbo-iliaca) is the aponeurotic investment of the psoas and iliacus muscle; and like the transversalis fascia, is thick below, and becomes gradually thinner as it ascends. It is attached superiorly, along the edge of the psoas, to the anterior lamella of the aponeurosis of the transversalis muscle, to the ligamentum arcuatum internum, and to the bodies of the lumbar vertebræ, leaving arches corresponding with the constricted part of the vertebræ for the transit of the lumbar vessels. Lower down it passes beneath the external iliac vessels, and is attached along the margin of the true pelvis; externally it is connected to the crest of the ilium; and, inferiorly, to the outer two-thirds of Poupart's ligament, where it is continuous with the transversalis fascia. Passing beneath Poupart's ligament, it surrounds the psoas and iliacus muscle to its termination, and beneath the inner part of the femoral arch forms the posterior segment of the crural canal or sheath of the femoral vessels.

The **PSOAS MAGNUS** (ψόα, lumbus, a loin), situated by the side of the vertebral column in the loins, is a long fusiform muscle. It *arises* from the bodies and bases of transverse processes of the last dorsal and all the lumbar vertebræ. It also takes its origin from the intervertebral substance, and from a series of tendinous arches

attached to the vertebræ, and intended for the protection of the lumbar vessels and branches of the sympathetic nerve in their passage between the muscle and the bone. From this extensive origin the muscle passes along the margin of the brim of the pelvis, and beneath Poupart's ligament, to its insertion. The tendon of the psoas magnus is joined by the iliacus, and *inserted* into the posterior part of the trochanter minor, a bursa being interposed.

Relations.—By its *anterior surface* with the ligamentum arcuatum internum of the diaphragm, kidney, psoas parvus, genito-crural nerve, sympathetic nerve, psoas fascia, peritoneum, colon, and along its pelvic border, the common and external iliac artery and vein. By its *posterior surface* with the lumbar vertebræ, lumbar arteries, quadratus lumborum (from which latter it is separated by the anterior layer of the aponeurosis of the transversalis), and crural nerve, which, near Poupart's ligament, reaches its outer side. The lumbar plexus of nerves is situated in the substance of the posterior part of the muscle. In the thigh the muscle is in relation with the fascia lata *in front;* the border of the pelvis and hip-joint, from which it is separated by the synovial membrane, common to it and the preceding muscle, *behind;* the crural nerve and iliacus muscle to the *outer* side; and the femoral artery, by which it is slightly overlaid, to the *inner* side.

Nerve Supply.—Branches from the lumbar plexus.

The **PECTINEUS** is a flat and quadrangular muscle; it *arises* from the pectineal line (*pecten*, a crest) of the os pubis, and from the surface of bone in front of that line. It is *inserted* into the ridge leading from the lesser trochanter to the linea aspera of the femur.

Relations.—By its *anterior surface* with the pubic portion of the fascia lata, which separates it from the femoral artery and vein and internal saphenous vein, and lower down with the profunda artery. By its *posterior surface* with the capsule of the hip-joint, obturator externus, and adductor brevis, the obturator vessels being interposed. By its *external border* with the psoas, the femoral artery resting on the line of interval. By its *internal border* with the outer edge of the adductor longus. Obturator hernia is situated directly behind this muscle, which forms one of its coverings.

Nerve Supply.—This muscle receives one branch from the anterior crural, and another from the obturator.

The **ADDUCTOR LONGUS** (*adducere*, to draw to), the most superficial of the three adductors, *arises* by a round and thick tendon from the front surface of the os pubis, immediately below the angle of that bone; and, assuming a flattened and expanded form as it descends, is *inserted* into the middle third of the inner lip of the linea aspera.

Relations.—By its *anterior surface* with the pubic portion of the fascia lata, and near its insertion, with the femoral artery and vein. By its *posterior surface* with the adductor brevis and magnus, anterior branches of the obturator vessels and nerve, and, near its

insertion, profunda artery and vein. By its *outer border* with the pectineus, by the *inner border* with the gracilis. The pectineus must be divided near its origin and turned outwards, and the adductor longus through its middle, turning its ends to either side, to bring into view the adductor brevis.

Nerve Supply.—Obturator nerve.

The **ADDUCTOR BREVIS**, placed behind the pectineus and adductor longus, is fleshy, and thicker than the adductor longus; it *arises* from the body of the os pubis, and is *inserted* into the line leading from the lesser trochanter to the linea aspera, immediately behind the insertion of the pectineus.

Nerve Supply.—Obturator nerve.

Relations.—By its *anterior surface* with the pectineus, adductor longus, and anterior branch of the obturator nerve and artery. By its *posterior surface* with the adductor magnus. By its *outer border* with the obturator externus, and tendon of the psoas and iliacus. By its *inner border* with the gracilis and adductor magnus. It is pierced near its insertion by the middle perforating artery. The adductor brevis may now be divided from its origin and turned outwards, or its inner two-thirds may be cut away entirely, when the adductor magnus muscle will be exposed in its entire extent.

The **ADDUCTOR MAGNUS** is a broad triangular muscle, forming a septum of division between the muscles situated on the anterior and those on the posterior aspect of the thigh. It *arises* by fleshy fibres from the ramus of the pubes and ischium and from the anterior border of the tuber ischii; and radiating in its passage outwards, is *inserted* into the line leading from the great trochanter to the linea aspera, to the whole length of the middle lip of the linea aspera, and by a rounded tendon into a small spine on the inner condyle of the femur. The adductor magnus is pierced by five openings; the three superior, for the three perforating arteries; the fourth, for the termination of the profunda. The fifth is the large oval opening, in the tendinous portion of the muscle, that gives passage to the femoral vessels.

Relations.—By its *anterior surface* with the pectineus, adductor brevis, adductor longus, femoral artery and vein, and profunda artery and vein, with their branches. By its *posterior surface* with the semi-tendinosus, semi-membranosus, biceps, and gluteus maximus. By its *inner border* with the gracilis and sartorius. By its *upper border* with the obturator externus and quadratus femoris.

Nerve Supply.—Obturator nerve.

The **GRACILIS** (slender) is situated along the inner border of the thigh. It *arises* by a broad but very thin tendon, from the body of the os pubis along the edge of the symphysis; and from the margin of the ramus of the pubes and ischium; it is *inserted* by a rounded tendon into the upper part of the inner side of the tibia, nearly as far forwards as the crest, beneath the expansion of the sartorius.

Relations.—By its *inner* or *superficial surface* with the fascia lata,

and below with the sartorius and internal saphenous nerve; the internal saphena vein crosses it lying superficially to the fascia lata. By its *outer* or *deep surface* with the adductor longus, brevis, and magnus, and the internal lateral ligament of the knee-joint, from which latter it is separated by a synovial bursa common to it and the tendons of the gracilis and semi-tendinosus.

Nerve Supply.—Obturator nerve.

Actions.—The iliacus, psoas, pectineus, and adductor longus muscles flex the thigh upon the pelvis, and at the same time, from the obliquity of their insertion into the lesser trochanter and linea aspera, rotate the limb outwards; the pectineus and adductors adduct the thigh powerfully, and from the manner of their insertion into the linea aspera, assist in rotating the limb outwards. The gracilis is an adductor of the thigh; but contributes to the flexion of the leg, by its attachment to the tibia.

Posterior Femoral Region.

Biceps femoris, Semi-tendinosus,
Semi-membranosus.

Dissection.—Remove the integument and fascia from the posterior part of the thigh by two flaps, and turn aside the gluteus maximus from the upper part; the muscles may then be examined.

The **BICEPS FEMORIS** (*bis*, double; *caput*, head; flexor cruris) *arises* by two heads, one (long head) by a common tendon with the semi-tendinosus from the upper and back part of the tuber ischii; the other (short head), muscular and much shorter, from the lower two-thirds of the external border of the linea aspera, external supracondylar ridge, and external intermuscular septum. The biceps forms the outer hamstring, and is *inserted* by a strong tendon into the head of the fibula; one portion of the tendon being continued downwards into the fascia of the leg, and another being attached to the outer tuberosity of the tibia. At its insertion into the fibula the tendon divides into two portions, between which the long external lateral ligament of the knee passes, a synovial bursa being interposed.

Relations.—By its *superficial* or *posterior surface* with the gluteus maximus and fascia lata. By its *deep* or *anterior surface* with the semi-membranosus, adductor magnus, vastus externus, from which it is separated by the external intermuscular septum, great ischiatic nerve, popliteal artery and vein, and near its insertion the external head of the gastrocnemius and plantaris. By its *inner border* with the semi-tendinosus, and in the popliteal space with the popliteal artery and vein.

Nerve Supply.—Great sciatic nerve.

The **SEMI-TENDINOSUS**, remarkable for its long tendon, *arises* in common with the long head of the biceps, from the upper and back part of the tuberosity of the ischium: the two muscles being closely united for several inches below their origin. It is *inserted*

into the upper part of the inner side of the tibia, nearly as far forwards as the crest, immediately below the insertion of the tendon of the gracilis, and sends an expansion to the fascia of the leg.

Relations.—By its *superficial surface* with the gluteus maximus, fascia lata, and at its insertion with the synovial bursa which separates its tendon from the expansion of the sartorius. By its *deep surface* with the semi-membranosus, adductor magnus, internal head of the gastrocnemius, and internal lateral ligament of the knee-joint, the synovial bursa common to it and the tendon of the gracilis being interposed. By its *inner border* with the gracilis; by its *outer border* with the biceps.

Nerve Supply. — Great sciatic nerve.

These two muscles must be dissected from the tuberosity of the ischium, to bring into view the origin of the next.

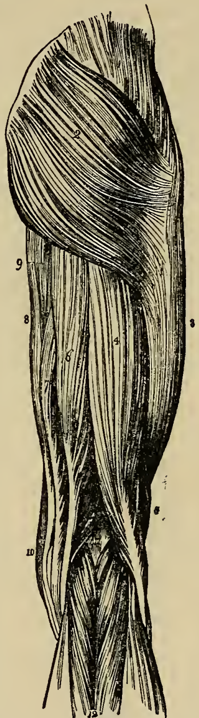


FIG. 223.—Muscles of the posterior femoral and gluteal region. 1. Gluteus medius. 2. Gluteus maximus. 3. Vastus externus covered in by fascia lata. 4. Long head of biceps. 5. Short head. 6. Semi-tendinosus. 7, 7. Semi-membranosus. 8. Gracilis. 9. Part of the inner border of the adductor magnus. 10. Edge of sartorius. 11. Popliteal space. 12. Gastrocnemius; its two heads. The tendon of the biceps forms the outer hamstring, the sartorius with the tendons of the gracilis, semi-tendinosus, and semi-membranosus, the inner hamstring.

The **SEMI-MEMBRANOSUS**, remarkable for the tendinous expansion upon its anterior and posterior surface, *arises* from the tuberosity of the ischium, in front of the common origin of the two preceding muscles. It is *inserted* into the posterior part of the inner tuberosity of the tibia; at its insertion the tendon splits into three portions, one of which is inserted in a groove on the inner side of the head of the tibia, beneath the internal lateral ligament. The second is continuous with an aponeurotic expansion that binds down the popliteus muscle, the popliteal fascia; and the third turns upwards and outwards to the external condyle of the femur, forming the middle portion of the posterior ligament of the knee-joint (ligamentum posticum Winslowii).

The tendons of the semi-tendinosus, semi-membranosus, gracilis, and sartorius, form the inner hamstring.

Relations.—By its *superficial surface* with the gluteus maximus, biceps, semi-tendinosus, fascia lata, and at its insertion, the tendinous expansion of the sartorius. By its *deep surface* with the

quadratus femoris, adductor magnus, internal head of gastrocnemius, knee-joint (from which it is separated by a synovial membrane), and the popliteal artery and vein. By its *inner border* with the gracilis. By its *outer border* with the great ischiatic nerve, and in the popliteal space the popliteal artery and vein.

Nerve Supply.—Great sciatic nerve.

If the semi-membranosus muscle be turned down from its origin, the student will bring into view the broad and radiated expanse of the adductor magnus, against which the three flexor muscles above described rest.

Actions.—The three hamstring muscles are flexors of the leg upon the thigh ; and taking their fixed point from below they extend the pelvis, and balance it on the lower extremities. The biceps, from the obliquity of its direction, everts the leg when partly flexed, and the semi-tendinosus turns the leg inwards when in the same state of flexion.

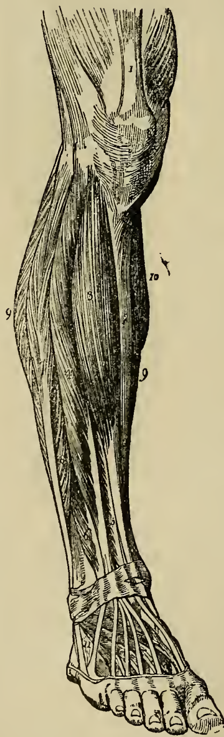


Fig. 224. — Muscles of the anterior tibial region. 1. Quadriceps extensor inserted into the patella ; the figure rests on the tendon of the rectus, the vastus internus and externus are situated one at each side. 2. Subcutaneous surface of the tibia. 3. Tibialis anticus. 4. Extensor longus digitorum. 5. Extensor proprius pollicis. 6. Peroneus tertius. 7. Peroneus longus. 8. Peroneus brevis. 9, 9. Borders of the soleus muscle. 10. Part of the inner belly of the gastrocnemius. 11. Extensor brevis digitorum ; the tendon in front of the number is that of the peroneus tertius ; that behind it, the peroneus brevis.

Anterior Tibial Region.

Tibialis anticus,
Extensor longus digitorum,
Peroneus tertius,
Extensor proprius pollicis.

Dissection. — The dissection of the anterior tibial region is to be commenced by carrying an incision along the middle of the leg midway between the tibia and fibula, from the knee to the ankle, and bounding it inferiorly by a transverse incision extending from one malleolus to the other. To expose the tendons on the dorsum of the foot, the longitudinal incision may be carried onwards to the outer side of the base of the great toe, and terminated by another incision directed across the heads of the metatarsal bones.

The **TIBIALIS ANTICUS** *arises* from the outer tuberosity and upper two-thirds of the outer surface of the tibia, the interosseous

membrane, intermuscular fascia, and deep fascia; its tendon passes through a distinct sheath in the anterior annular ligament, and is *inserted* into the inner and under side of the internal cuneiform bone, and base of the metatarsal bone of the great toe.

Relations.—By its *anterior surface* with the deep fascia from which many of its superior fibres arise, and the anterior annular ligament. By its *posterior surface* with the interosseous membrane, tibia, ankle-joint, and bones of the tarsus. By its *internal surface* with the tibia; by its *external surface* with the extensor longus digitorum, extensor proprius pollicis, and anterior tibial vessels and nerve.

Nerve Supply.—Anterior tibial nerve.

The **EXTENSOR LONGUS DIGITORUM** (extensor communis longus) *arises* from the outer tuberosity of the tibia, the head and upper three-fourths of the fibula, the interosseous membrane, intermuscular fascia, and deep fascia. Near the ankle it divides into four tendons, which pass beneath the annular ligament through a proper tendinous pulley (the sling ligament of Retzius), to be *inserted* into the second and third phalanges of the four lesser toes. The mode of insertion of the extensor tendons, both in the hand and in the foot, is remarkable; each tendon spreads into a broad aponeurosis over the first phalanx; this aponeurosis is strengthened on its borders by the tendons of the lumbricales and interossei, and divides into three slips; the middle slip is inserted into the base of the second phalanx, the two lateral slips are continued onwards, to be inserted into the base of the third.

Relations.—By its *anterior surface* with the deep fascia of the leg and foot, and anterior annular ligament. By its *posterior surface* with the interosseous membrane, fibula, ankle-joint, extensor brevis digitorum (which separates its tendons from the tarsus), metatarsus, and phalanges. By its *inner surface* with the tibialis anticus, extensor proprius pollicis, and anterior tibial vessels. By its *outer border* with the peroneus longus and brevis.

Nerve Supply.—This muscle and the next are both supplied by the anterior tibial nerve.

The **PERONEUS TERTIUS** *arises* from the lower fourth of the inner surface of the fibula and intermuscular fascia, and is *inserted* into the upper surface of the base of the metatarsal bone of the little toe. Although apparently but a mere division or continuation of the extensor longus digitorum, this muscle may be looked upon as homologous to the flexor carpi ulnaris of the forearm. Sometimes it is wanting.

The **EXTENSOR PROPRIUS POLLICIS** (extensor hallucis longus) lies between the tibialis anticus and extensor longus digitorum. It *arises* from the middle three-fifths of the fibula and interosseous membrane. Its tendon passes through a distinct sheath in the annular ligament, and is *inserted* into the base of the last phalanx of the great toe, being closely connected with the first phalanx by short fibrous bands.

Relations.—By its *anterior surface* with the deep fascia of the leg and foot, and anterior annular ligament. By its *posterior surface* with the interosseous membrane, fibula, tibia, ankle-joint, extensor brevis digitorum, and bones and articulations of the great toe. It is crossed on this aspect by the anterior tibial vessels and nerve. By its *outer side* with the extensor longus digitorum, and in the foot with the dorsalis pedis artery and veins; the outer side of its tendon on the dorsum of the foot being the guide to these vessels. By its *inner side* with the tibialis anticus, and anterior tibial vessels.

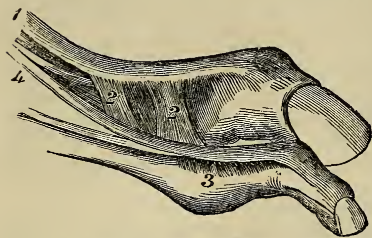


FIG. 225.—Insertion of extensors of toes. 1. Extensor proprius pollicis. 2, 2. Fibrous bands passing to first phalanx of great toe. 3. Fibrous bands from 4, Extensor longus digitorum.

Nerve Supply.—Anterior tibial nerve.

Actions.—The tibialis anticus and peroneus tertius are direct flexors of the tarsus upon the leg. The two tibial muscles acting together raise the inner border of the foot and draw it inwards. They assist also in preserving the arch of the foot during progression. The extensor longus digitorum and extensor proprius pollicis are extensors of the phalanges; and continuing their action, they assist the tibialis anticus and peroneus tertius in flexing the foot upon the leg. Taking their origin from below, they increase the stability of the ankle-joint.

Posterior Tibial Region.

Superficial Group.

Gastrocnemius, Plantaris, Soleus.

Dissection.—Make an incision from the middle of the popliteal space down the middle of the posterior part of the leg to the heel, bounding it inferiorly by a transverse incision passing between the two malleoli. Turn aside the flaps of integument and remove the fasciæ from the whole of this region: the gastrocnemius muscle will then be exposed.

The **GASTROCNEMIUS** (γαστροκνήμιον, the bellied part of the leg) *arises* by two heads from the upper part of the two condyles of the femur, the inner head being the longest. They unite to form the beautiful muscle so characteristic of this region of the limb. It is *inserted*, by means of the tendo-Achillis, into the lower part of the posterior tuberosity of the os calcis, a synovial bursa being placed between the tendon and the upper part of the tuberosity. The gastrocnemius must be removed from its origin, and turned down in order to expose the next muscle.

Relations.—By its *superficial surface* with the deep fascia of the

leg, which separates it from the external saphena vein, and with the external saphenous nerve. By its *deep surface* with the lateral portions of the posterior ligament of the knee-joint, the popliteus, plantaris, and soleus. The internal head of the muscle rests against the posterior surface of the internal condyle of the femur, and is separated from the semimembranosus by a synovial bursa which often communicates with the cavity of the knee-joint. The external head rests against the outer side of the external condyle, and sometimes has in it a sesamoid bone or fibro-cartilage.

Nerve Supply.—Internal popliteal nerve.

The **PLANTARIS** (*planta*, the sole of the foot), an extremely diminutive muscle situated between the gastrocnemius and soleus, *arises* from the upper part of the outer condyle of the femur; and is *inserted*, by its long and delicately slender tendon, into the inner side of the posterior tuberosity of the os calcis, by the side of the tendo-Achillis, having crossed obliquely between the two muscles. It corresponds to the palmaris longus in the fore-arm.

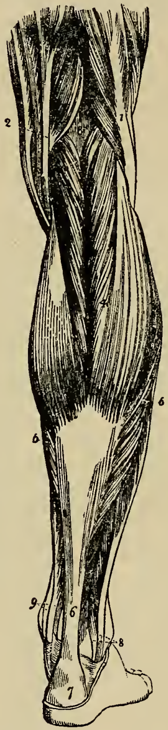


Fig. 226.—Superficial muscles of the posterior aspect of the leg. 1. Biceps, forming the outer hamstring. 2. Tendons, forming the inner hamstring. 3. Popliteal space. 4. Gastrocnemius. 5, 5. Soleus. 6. Tendo-Achillis. 7. Posterior tuberosity of the os calcis. 8. Tendons of the peroneus longus and brevis passing behind the outer ankle. 9. Tendons of the tibialis posticus and flexor longus digitorum passing into the foot behind the inner ankle.

Nerve Supply.—Internal popliteal nerve.

The **SOLEUS** (*solea*, a sole) is the broad muscle upon which the plantaris rests. It *arises* from the head and upper half of the fibula, from the oblique line and middle third of the inner border of the tibia, and from a tendinous arch thrown across between these two portions. Its fibres converge to the tendo-Achillis, by which it is *inserted* into the posterior tuberosity of the os calcis. The tendinous arch gives passage to the popliteal vessels and nerve in their course to the leg.

Relations.—By its *superficial surface* with the gastrocnemius and plantaris. By its *deep surface* with the intermuscular fascia, which separates it from the flexor longus digitorum, tibialis posticus, flexor longus pollicis, posterior tibial vessels and nerve, and peroneal vessels.

Nerve Supply.—Internal popliteal.

Actions.—The three muscles of the calf draw powerfully on the os calcis, and lift the heel; continuing their action they raise the entire body. This movement is attained by means of a lever of the second power, the fulcrum (the toes) being at one end, the weight (the body supported on the tibia) in the middle, and the power (these muscles) at the other extremity.

They are, therefore, the walking muscles, and perform all movements that require the support of the whole body from the ground, as dancing, leaping, &c. Taking their fixed point from below, they steady the leg upon the foot. The gastrocnemius is also a powerful flexor of the leg on the thigh.

Deep Layer.

Popliteus,	Flexor longus digitorum,
Flexor longus pollicis,	Tibialis posticus.

Dissection.—After the removal of the soleus, the deep layer will be found bound down by an intermuscular fascia which is to be dissected away; the muscles may then be examined.

The **POPLITEUS** muscle (*poples*, the ham of the leg) forms the floor of the popliteal region at its lower part, and is bound tightly down by a strong fascia derived from the middle slip of the tendon of the semi-membranosus muscle. It *arises* by a rounded tendon from a deep groove at the outer side of the external condyle of the femur, beneath the external lateral ligament and within the capsular ligament of the joint; and spreading obliquely over the head of the tibia, is *inserted* into the surface of the bone above its oblique line. This line is sometimes called, from being the limit of insertion of the popliteus muscle, the *popliteal line.* During flexion of the limb, the tendon of origin of this muscle lies in the groove on the outer side of the external condyle of the femur. It is homologous with the pronator radii teres in the forearm.

Relations.—By its *superficial surface* with a thick fascia which separates it from the gastrocnemius, plantaris, and popliteal vessels and nerve. By its *deep surface* with the synovial membrane of the knee-joint, and upper part of the tibia.

Nerve Supply.—Internal popliteal.

The **FLEXOR LONGUS POLLICIS** (flexor hallucis longus) is the most superficial of the next three muscles. It *arises* from the lower two-thirds of the internal surface of the fibula excepting about an inch at its lowest part, and passes through a groove in the astragalus and os calcis, converted by tendinous fibres into a distinct sheath lined by synovial membrane, into the sole of the foot, to be *inserted* into the base of the last phalanx of the great toe.

Relations.—By its *superficial surface* with the intermuscular fascia, which separates it from the soleus and tendo-Achillis. By its *deep surface* with the tibialis posticus, fibula, peroneal vessels, interosseous membrane, and ankle-joint. By its *outer border* with the

peroneus longus and brevis. By its *inner border* with the flexor longus digitorum. In the foot, the tendon of the flexor longus pollicis is connected with that of the flexor longus digitorum by a short tendinous slip.

Nerve Supply.—Posterior tibial nerve.

The **FLEXOR LONGUS DIGITORUM** (perforans; flexor communis longus) *arises* from the posterior surface of the tibia, extending from the oblique line to within three inches of the inner ankle. Its tendon passes through a sheath, common to it and the tibialis posticus, behind the inner malleolus; it then passes through a second sheath which is connected with a groove in the astragalus and os calcis into the sole of the foot where it divides into four tendons, which are *inserted* into the base of the last phalanx of the four lesser toes, perforating the tendons of the flexor brevis digitorum.

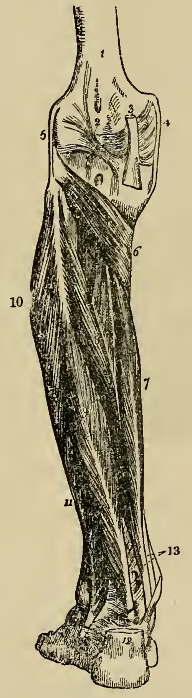


FIG. 227.—Deep layer of muscles of the posterior tibial region. 1. Lower extremity of the femur. 2. Ligamentum posticum Winslowii. 3. Tendon of the semimembranosus muscle dividing into three slips. 4. Internal lateral ligament of the knee-joint. 5. External lateral ligament. 6. Popliteus muscle. 7. Flexor longus digitorum. 8. Tibialis posticus. 9. Flexor longus pollicis. 10. Peroneus longus. 11. Peroneus brevis. 12. Tendo-Achillis divided near its insertion into the os calcis. 13. Tendons of the tibialis posticus and flexor longus digitorum, just as they are about to pass beneath the internal annular ligament of the ankle; the interval between the latter tendon and the tendon of the flexor longus pollicis is for the posterior tibial vessels and nerve.

Relations.—By its *superficial surface* with the intermuscular fascia, which separates it from the soleus, and with the posterior tibial vessels and nerve. By its *deep surface* with the tibia and tibialis posticus. In *the sole of the foot* its tendon is in relation with the abductor pollicis and flexor brevis digitorum, which lie superficially to it, and it crosses the tendon of the flexor longus pollicis. At the point of crossing it receives a tendinous slip of communication.

Nerve Supply.—Posterior tibial.

Dissection.—The flexor longus pollicis must now be removed from its origin, and the flexor longus digitorum drawn aside, to bring into view the entire extent of the tibialis posticus.

The **TIBIALIS POSTICUS** lies upon the interosseous membrane, between the two bones of the leg. It *arises* by two heads from the adjacent sides of the tibia and fibula their whole length except about two inches at the lower end, from the interosseous

membrane, and from an aponeurosis which binds it in its place. Its tendon passes inwards beneath the tendon of the flexor longus digitorum, and runs in the same sheath; it then passes through a proper sheath over the deltoid ligament, and beneath the astragalo-scaphoid articulation, to be *inserted* into the tuberosity of the scaphoid and internal cuneiform bone, a process of its tendon being prolonged outwards to the external cuneiform, and other processes being connected with the middle cuneiform, the cuboid, and the bases of the second, third, and fourth metatarsal bones. While in the common sheath behind the internal malleolus, the tendon of the tibialis posticus lies internally to that of the flexor longus digitorum, from which it is separated by a thin fibrous partition. A sesamoid bone is usually met with in the tendon close to its insertion.

Relations.—By its *superficial surface* with the intermuscular septum, flexor longus pollicis, flexor longus digitorum, posterior tibial vessels and nerve, peroneal vessels, and in the sole of the foot the abductor pollicis. By its *deep surface* with the interosseous membrane, fibula and tibia, ankle-joint and astragalus. The anterior tibial artery passes between the two heads of the muscle.

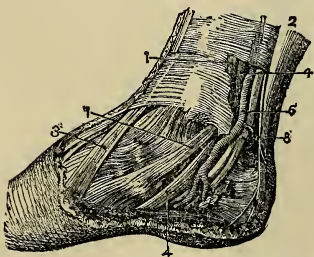


Fig. 228.—Relations of parts behind the inner malleolus. 1, 1. Tibialis posticus. 2. Tendo-Achillis. 3. Tibialis anticus. 4, 4. Flexor longus digitorum. 6. Posterior tibial artery. 8. Posterior tibial nerve. The tendon of the flexor longus pollicis is too deeply placed to be shown in this view.

Nerve Supply. — Posterior tibial.

The student will observe that the two latter muscles change their relative position to each other in their course. Thus, in the leg, the position of the three muscles from within outwards is, flexor longus digitorum, tibialis posticus, flexor longus pollicis. At the inner malleolus, the relation of the tendons is, tibialis posticus, flexor longus digitorum, both in the same sheath; then a broad groove, which lodges the posterior tibial artery, venæ comites, and nerve; and lastly, the flexor longus pollicis.

Actions.—The popliteus is a flexor of the tibia upon the thigh, carrying it at the same time inwards so as to invert the leg, the joint being so arranged that rotation is only possible when the leg is flexed. The flexor longus pollicis and flexor longus digitorum are the long flexors of the toes; their tendons are connected in the foot by a short tendinous band, hence they necessarily act together. The tibialis posticus is an extensor of the tarsus upon the leg, and an antagonist to the tibialis anticus. It combines with the tibialis anticus in adduction of the foot.

Fibular Region.

Peroneus longus, Peroneus brevis.

Dissection.—These muscles are exposed by continuing the dissection of the anterior tibial region outwards beyond the fibula to the border of the posterior tibial region.

The **PERONEUS LONGUS** (περόνη, fibula) *arises* from the head and upper two-thirds of the outer side of the fibula, from the deep fascia and intermuscular septa, and terminates in a long tendon which passes behind the external maleolus, and obliquely across the sole of the foot, through the groove in the cuboid bone, to be *inserted* into the base of the metatarsal bone of the great toe and under surface of the internal cuneiform bone. Its tendon is thickened where it glides behind the external malleolus, and a sesamoid bone is developed in that part which plays against the cuboid bone.

Relations.—By its *superficial surface* with the fascia of the leg and foot. By its *deep surface* with the fibula, peroneus brevis, os calcis, cuboid bone, and, near the head of the fibula, the external popliteal nerve. By its *anterior border* it is separated from the extensor longus digitorum by the attachment of the fascia of the leg to the fibula ; and, by the *posterior border*, by the same medium from the soleus and flexor longus pollicis. The tendon of the peroneus longus is furnished with three fibrous sheaths and as many synovial membranes ; the first is situated behind the external malleolus, and is common to this muscle and the peroneus brevis, the second at the outer side of the os calcis, the third on the cuboid bone.

Nerve Supply.—Musculo-cutaneous nerve, a branch of the peroneal nerve.

The **PERONEUS BREVIS** lies beneath the peroneus longus ; it *arises* from the lower two-thirds of the fibula and intermuscular septa, and terminates in a tendon which passes behind the external malleolus and through a groove in the os calcis, to be *inserted* into the base of the metatarsal bone of the little toe.

Relations.—By its *superficial surface* with the peroneus longus and fascia of the leg and foot. By its *deep surface* with the fibula, os calcis, and cuboid bone. The lateral relations of the muscle are the same as those of the peroneus longus. The tendon of the peroneus brevis has but two tendinous sheaths and two synovial membranes, one being behind the external malleolus and common to both peronei, the other at the side of the os calcis.

Nerve Supply.—Musculo-cutaneous nerve.

Actions.—The peronei muscles are extensors of the foot, conjointly with the tibialis posticus. They antagonise the tibialis anticus and peroneus tertius, which are flexors of the foot ; they also raise the outer border of the foot and draw it outwards. The whole of these muscles acting together, tend to maintain the arch of the foot, so necessary to security in walking.

Foot.

Dorsal Region.

Extensor brevis digitorum, Dorsal interossei.

The **EXTENSOR BREVIS DIGITORUM** muscle *arises* from the outer side of the os calcis, and from the lower part of the anterior annular ligament; it crosses the foot obliquely, and terminates in four tendons, the innermost of which is *inserted* into the base of the first phalanx of the great toe, and the other three into the side of the long extensor tendons of the second, third, and fourth toes.

Relations.—By its *upper surface* with the tendons of the extensor longus digitorum, peroneus brevis, and the deep fascia of the dorsum of the foot. By its *under surface* with the tarsal and metatarsal bones. Its *inner border* is in relation with the dorsalis pedis artery, the innermost tendon crossing that artery just before its division.

Nerve Supply.—Anterior tibial nerve.

The **DORSAL INTEROSSEI** muscles, four in number, are placed between the metatarsal bones; they resemble the corresponding muscles in the hand in *arising* by two heads from the adjacent sides of the metatarsal bones; their tendons are *inserted* into the base of the first phalanx, and the digital expansion of the tendons of the long extensor. The dorsal interossei muscles all *abduct* from the middle line of the second toe.

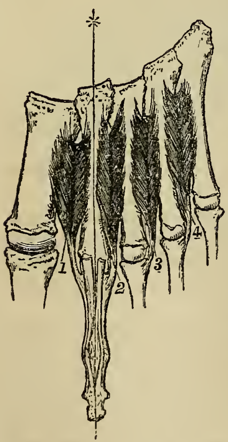


Fig. 229.—Diagram of the dorsal interosseous muscles of the foot; designed to show that they all *abduct* from the middle line of the second toe.

Relations.—By their *upper surface* with a strong fascia which separates them from the extensor tendons. By their *under surface* with the plantar interossei. Each of the muscles gives passage to a small artery (posterior perforating) which communicates with the external plantar artery; and between the heads of the first interosseous muscle the dorsalis pedis artery takes its course.

Plantar Region.

First Layer.

Abductor pollicis, Abductor minimi digiti,
Flexor brevis digitorum.

Dissection.—The sole of the foot is best dissected by carrying an incision around the heel and along the inner and outer border of the foot, to the great and little toe. This incision should divide the integument and superficial fascia, and both together should be dissected from the

deep fascia, as far forward as the base of the phalanges, where they should be removed from the foot altogether. The plantar fascia should then be raised by a transverse incision made through it at about the middle of the foot, and should be turned over towards the toes; the first layer of muscles will thus be brought into view.

The **ABDUCTOR POLLICIS** (vel hallucis) lies along the inner border of the foot; it *arises* by two heads, between which the tendons of the long flexors, arteries, veins, and nerves enter the sole of the foot. One head proceeds from the inner tuberosity of the os calcis, the other from the internal annular ligament and plantar fascia; it is *inserted* along with the inner head of the flexor brevis pollicis into the base of the first phalanx of the great toe, and into the internal sesamoid bone.

Relations.—By its *superficial surface* with the internal portion of the plantar fascia. By its *deep surface* with the flexor brevis pollicis, musculus accessorius, tendons of the flexor longus digitorum, flexor longus pollicis, tibialis anticus and posticus, plantar vessels and nerves, and tarsal bones. At its *outer border* with the flexor brevis digitorum, from which it is separated by a vertical septum of the plantar fascia.

Nerve Supply.—Internal plantar nerve.

The **ABDUCTOR MINIMI DIGITI** lies along the outer border of the sole of the foot. It *arises* from the outer tuberosity of the os calcis, the surface between the two tuberosities, the external intermuscular septum, and from the plantar fascia as far forward as the base of the fifth metatarsal bone; and is *inserted* into the base of the first phalanx of the little toe.

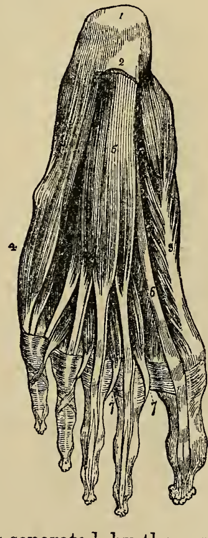


Fig. 230. — First layer of muscles of the sole of the foot; this layer is exposed by the removal of the plantar fascia. 1. Os calcis. 2. Posterior part of the plantar fascia divided transversely. 3. Abductor pollicis. 4. Abductor minimi digiti. 5. Flexor brevis digitorum. 6. Tendon of the flexor longus pollicis. 7, 7. Lumbricales. On the second and third toe, the tendons of the flexor longus digitorum are seen passing through the bifurcation of the tendons of the flexor brevis digitorum.

Relations. — By its *superficial surface* with the external portion of the plantar fascia. By its *deep surface* with the musculus accessorius, flexor brevis minimi digiti, tarsal bones, and metatarsal bone of the little toe. By its *inner side* with the flexor brevis digitorum, from which it is separated by the vertical septum of the plantar fascia.

Nerve Supply.—External plantar nerve.

The **FLEXOR BREVIS DIGITORUM** (perforatus) is placed between the two preceding muscles. It *arises* from the under surface of the os calcis, from the plantar fascia, and intermuscular septa; and is *inserted* by four tendons into the base of the second phalanx of the four lesser toes. Each tendon divides, previously to its insertion, to give passage to the tendon of the long flexor; hence its cognomen *perforatus*.

Relations.—By its *superficial surface* with the plantar fascia. By its *deep surface* with a thin layer of fascia which separates it from the musculus accessorius, tendons of the flexor longus digitorum and flexor longus pollicis, and plantar vessels and nerves. By its *borders* with the vertical septa of the plantar fascia which separate the muscle, on the one side from the abductor pollicis, and on the other from the abductor minimi digiti.

Nerve Supply.—Internal plantar nerve.

Second Layer.

Musculus accessorius, Lumbricales.

Dissection.—The three preceding muscles must be divided near their origin, and turned downwards, in order to see the muscles of this group, but they must not be entirely removed.

FIG. 231.—Third and part of second layer of the muscles of the sole of the foot. 1. Divided edge of the plantar fascia. 2. Musculus accessorius. 3. Tendon of the flexor longus digitorum. 4. Tendon of the flexor longus pollicis. 5. Flexor brevis pollicis. 6. Adductor pollicis. 7. Flexor brevis minimi digiti. 8. Transversus pedis. 9. Interossei muscles, plantar and dorsal. 10. Ridge formed by the tendon of the peroneus longus in its oblique course across the foot.

The **MUSCULUS ACCESSORIUS** *arises* by two slips, the inner of which is fleshy and the outer tendinous; the former is attached to the inner surface of the os calcis, and the latter to the under surface of the same bone a little in front of the outer tuberosity, and to the long plantar ligament. It is *inserted* into the outer border, and upper and lower. surfaces of the long flexor tendon.

Relations.—By its *superficial surface* with the three muscles of the superficial layer, from which it is separated by their fascial sheaths, and with the external plantar vessels and nerve. By its *deep surface* with the under part of the os calcis and long plantar ligament.

Nerve Supply.—External plantar nerve.

The **LUMBRICALES** (*lumbricus*, an earth-worm) are four little

muscles *arising* from the tendons of the flexor longus digitorum at their point of bifurcation, each, with the exception of the most internal, being attached to two tendons; they are *inserted* into the expansion of the extensor tendons, and the base of the first phalanx of the four lesser toes on their inner side. They pass between the digital slips of the plantar fascia to their insertion.

Nerve Supply.—The two inner by digital branches of the internal plantar nerve, the two outer by the deep branch of the external plantar.

Third Layer.

Flexor brevis pollicis,	Transversus pedis,
Adductor pollicis,	Flexor brevis minimi digiti.

Dissection.—The tendons of the long flexors and the muscles connected with them must be removed, to see clearly the attachments of the third layer.

The **FLEXOR BREVIS POLLICIS** *arises* by a pointed tendinous process from the side of the cuboid, external cuneiform bone, and expanded tendon of the tibialis posticus; it is *inserted* by two heads into the outer and inner sides of the base of the first phalanx of the great toe. Two sesamoid bones are developed in the tendons of insertion of these two heads, and the tendon of the flexor longus pollicis lies in the groove between them.

Relations.—By its *superficial surface* with the abductor pollicis, tendon of the flexor longus pollicis, and plantar fascia. By its *deep surface* with the tarsal bones, metatarsal bone of the great toe, and insertion of the tendon of the peroneus longus. By its *inner border* with the abductor pollicis; and by its *outer border* with the adductor pollicis; with both of which muscles it is blended near its insertion.

Nerve Supply.—Internal plantar nerve.

The **ADDUCTOR POLLICIS** *arises* from the cuboid bone, the sheath of the tendon of the peroneus longus, and the base of the third and fourth metatarsal bones. It is *inserted* into the base of the first phalanx of the great toe, in conjunction with the outer head of the flexor brevis pollicis.

Relations.—By its *superficial surface* with the tendons of the flexor longus and flexor brevis digitorum, musculus accessorius, and lumbricales. By its *deep surface* with the tarsal bones and ligaments, external plantar artery and veins, interossei muscles, tendon of the peroneus longus, and metatarsal bone of the great toe. By its *inner border* with the flexor brevis pollicis, with which its fibres are blended.

Nerve Supply.—External plantar.

The **TRANSVERSUS PEDIS** *arises* by fleshy slips from the heads of the metatarsal bones and inner metatarso-phalangeal ligaments of the four lesser toes. It passes transversely inwards to be *inserted* into the base of the first phalanx of the great toe, its tendon being blended with that of the adductor pollicis.

The transversus pedis is regarded by some anatomists as a short

head of the adductor pollicis; in its action it is obviously an adductor; while the adductor pollicis is as much a flexor as an adductor.

Relations.—By its *superficial surface* with the tendons of the flexor longus and flexor brevis digitorum, and lumbricales. By its *deep surface* with the interossei and ligaments of the metatarso-phalangeal articulations.

Nerve Supply.—External plantar.

The **FLEXOR BREVIS MINIMI DIGITI** *arises* from the base of the metatarsal bone of the little toe, and the sheath of the tendon of the peroneus longus. It is *inserted* into the base of the first phalanx of the little toe at its outer side.

Relations.—By its *superficial surface* with the tendons of the flexor longus and flexor brevis digitorum, the fourth lumbricalis, abductor minimi digiti, and plantar fascia. By its *deep surface* with the plantar interosseous muscle of the fourth metatarsal space, and the fifth metatarsal bone.

Nerve Supply.—External plantar.

Fourth Layer.

Plantar interossei.

The **PLANTAR INTEROSSEI** muscles are three in number, and are placed *upon* rather than between the metatarsal bones. They *arise* from the base and inner side of the shaft of the metatarsal bone of the three outer toes, and are *inserted* into the inner side of the extensor tendon and base of the first phalanx of the same toes.

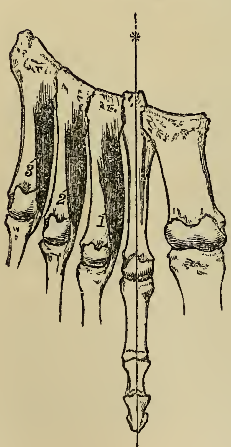


Fig. 232.—Diagram of the plantar interosseous muscles, designed to show that they are all *adductors* to the middle line of the second toe.

The plantar interosseous all draw towards the middle line of the *second* toe, the dorsal draw from that line; hence the former are *abductors*, the latter *adductors*. A like arrangement exists in the hand, with this difference, that the middle finger is the one through which the central line is drawn.

Relations.—By their *superficial surface* with the dorsal interossei and metatarsal bones. By their *deep surface* with the external plantar artery and veins, adductor pollicis, transversus pedis, and flexor minimi digiti.

Actions.—All the preceding muscles act upon the toes; and the movements which they are capable of executing may be referred to four heads—viz., flexion, extension, adduction, and abduction. In these actions they are grouped in the following manner :—

Flexion.	*Extension.*
Flexor longus digitorum, Flexor brevis digitorum, Flexor accessorius, Flexor minimi digiti.	Extensor longus digitorum, Extensor brevis digitorum.
Adduction.	*Abduction.*
Interossei, three plantar.	Interossei, four dorsal, Abductor minimi digiti.

The great toe, like the thumb in the hand, enjoys an independent action, and is provided with distinct muscles to perform its movements. These movements are precisely the same as those of the other toes, viz.:—

Flexion.	*Extension.*
Flexor longus pollicis, Flexor brevis pollicis.	Extensor proprius pollicis, Extensor brevis digitorum.
Adduction.	*Abduction.*
Adductor pollicis, Transversus pedis.	Abductor pollicis.

The only muscles excluded from this table are the lumbricales, four small muscles, which, from their attachments to the tendons of the long flexor, appear to be assistants in its actions.

PART V.

ANGIOLOGY.

In the section on Histology two sets of vessels have been described, namely, those carrying blood and those carrying lymph, and the former have further been divided into arteries, veins, and capillaries. The description of the capillaries can, however, only be satisfactorily given in connection with the organs of which they form a part, so that their arrangement and distribution will not now occupy our attention. The present section will therefore be devoted to the description of the arteries, veins, and lymphatics.

ARTERIES.

In the consideration of the arteries, the aorta will be first described with the branches of that trunk and their subdivisions, which together constitute the efferent portion of the systemic circulation; and then the pulmonary artery as the efferent trunk of the pulmonary circulation.

AORTA.

The aorta arises from the base of the left ventricle, at the middle of the root of the heart on a level with the body of the sixth dorsal vertebra, and presents at its commencement an enlargement (bulbus aortæ) caused by three dilatations of the walls of the vessel, the *sinus aortici* (sinuses of Valsalva), and corresponding with the three semilunar valves. It ascends at first forwards and to the right, then curves backwards and to the left, and descends on the left side of the vertebral column to the fourth lumbar vertebra. Hence it is divided into the arch and descending aorta.

The ARCH OF THE AORTA commencing at a point corresponding with the articulation of the cartilage of the third rib with the sternum on the left side, crosses behind and near the sternum to a point corresponding with the upper border of the articulation of the second rib with the sternum on the right side. It then curves

backwards and to the left, and descends to the left side of the body of the fifth dorsal vertebra, and at the lower border of the latter vertebra becomes the thoracic aorta.

The first or **ascending** portion of the arch, a little more than two inches in length, is almost wholly contained within the pericardium; it extends from the third costal cartilage of the left side, to the upper border of the second cartilage of the right side, at its junction with the sternum. It is crossed *in front* by the pulmonary artery; on its *left* side it has the left auricle and pulmonary artery; on its

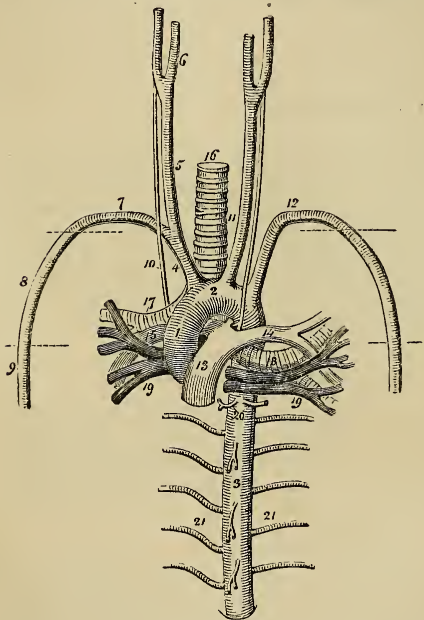


FIG. 233.—The large vessels of the root of the heart and lungs. 1. Ascending aorta. 2. Transverse portion of the arch. 3. Thoracic or descending aorta. 4. Arteria innominata. 5. Right common carotid. 6. External and internal carotids. 7. Right subclavian artery. 8. Axillary artery. 9. Brachial artery. 10. Right pneumogastric nerve. 11. Left common carotid. 12. Left subclavian artery. 13. Pulmonary artery. 14. Left pulmonary artery. 15. Right pulmonary artery. 16. Trachea. 17. Right bronchus. 18. Left bronchus. 19, 19. Pulmonary veins, 17, 15, 19, on the right side, and 14, 18, 19, on the left, constitute the roots of the corresponding lungs, and the relative position of the vessels is preserved. 20. Bronchial arteries. 21, 21. Intercostal arteries; the branches from the front of the aorta above and below the number 3 are pericardiac and œsophageal.

right the right auricle and superior vena cava; and *behind* the right pulmonary artery and veins.

The second or **transverse** portion of the arch is directed backwards and to the left, and extends from the second costal cartilage on the right side to the left side of the body of the fourth dorsal vertebra. It is crossed *in front* by the left phrenic nerve, left superior cardiac nerve, left inferior cardiac of the pneumogastric, and left pneumogastric nerve. *Behind* it is in relation with the trachea, œsophagus, thoracic duct, nerves to the deep cardiac plexus, and left recurrent laryngeal nerve. *Above* it gives off the arteria innominata, left carotid and left subclavian artery, and has lying on

it the left vena innominata ; and *below* is in relation with the superficial cardiac plexus, bifurcation of the pulmonary artery, cord of the ductus arteriosus, left bronchus, and left recurrent nerve.

The third or **descending** portion of the arch lies against the fifth dorsal vertebra, and is partially covered by the left pleura. It is in relation *in front* with the pleura and root of the left lung, *behind* with the body of the fifth dorsal vertebra, on the *right side* with the œsophagus and thoracic duct, and on the *left* with the pleura.

Descending Aorta.—The descending aorta is subdivided, in correspondence with the two great cavities of the trunk, into the thoracic and abdominal aorta.

Thoracic Aorta.—The thoracic aorta commencing at the lower border and left side of the fifth dorsal vertebra curves gently towards the right as it descends, and as it passes through the aortic opening of the diaphragm lies on the middle line of the vertebral column.

It is in relation *behind*, with the vertebral column and lesser vena azygos ; *in front*, with the œsophagus, left pulmonary artery, left bronchus, pericardium, and right pneumogastric nerve ; to the *left side*, with the pleura, left lung, and œsophagus ; and to the *right*, with the œsophagus, vena azygos major, and thoracic duct.

Abdominal Aorta.—The aorta enters the abdomen through a special opening in the diaphragm, and, as it lies against the body of the last dorsal vertebra, receives the name of *abdominal aorta;* it passes downwards, and on the fourth lumbar vertebra, a little to the left of the middle line, divides into the two common iliac arteries. Its relations and branches will be described on a later page.

Branches.—The branches of the aorta, arranged in a tabular form, are as follows :—

- **Arch**
  - *ascending portion*, Coronary, right and left.
  - *transverse portion*,
    - Innominate artery,
      - Right cartoid,
      - Right subclavian.
    - Left carotid,
    - Left subclavian,
- **Thoracic aorta**
  - Pericardiac,
  - Bronchial,
  - Œsophageal,
  - Intercostal.
- **Abdominal aorta** . . . .
  - Phrenic,
  - Cœliac axis
    - Gastric,
    - Hepatic,
    - Splenic.
  - Supra-renal,
  - Renal,
  - Superior mesenteric,
  - Spermatic,
  - Inferior mesenteric,
  - Lumbar,
  - Sacra-media,
  - Common iliacs.

Varieties of the Aorta.—The aorta seldom deviates from the course and relations above described. In some few cases there is

persistence of the double arch which exists in the early stages of the development of the vascular system, and in rare instances the aortic arch turns to the right side instead of the left, this being frequently accompanied by complete transposition both of the thoracic and abdominal viscera. Varieties in the primary branches of the arch are by no means uncommon. That which is by far the most frequent is the origin of the left vertebral from the arch; next in frequency we have the origin of both carotids and the right subclavian in common from the innominate, so that the primary branches of the transverse arch are reduced to two; occasionally, also, there is absence of the innominate, all four branches arising directly from the arch.

The **CORONARY ARTERIES** arise from the two anterior of the three aortic sinuses at the commencement of the ascending portion of the arch of the aorta, immediately above the free margin of the semilunar valves.

The **left coronary** passes forwards, between the pulmonary artery and left auricular appendix, and divides into two branches; one of which (posterior) winds around the base of the left ventricle in the auriculo-ventricular groove, and reaches nearly as far as the corresponding branch of the right coronary; the other (anterior) passes along the groove of union of the two ventricles, on the anterior aspect of the heart, to its apex, giving off branches in its course to the ventricular walls. The left coronary artery supplies the left auricle and anterior surface of both ventricles.

The **right coronary** passes forwards, between the root of the pulmonary artery and the right auricle, and running from left to right in the auriculo-ventricular groove, descends along the posterior aspect of the heart to its apex, giving off twigs which supply the posterior aspect of both ventricles.

Experimental injections of the coronary arteries have shown that they do not anastomose in the auriculo-ventricular and inter-ventricular grooves as was formerly supposed and described; it being found impossible to inject one coronary artery with material introduced into the other.

INNOMINATE ARTERY.

The innominate artery (brachio-cephalic) (fig. 233, 4) is the first and largest artery given off by the arch of the aorta. It is an inch and a half in length, and arises from the arch behind the junction of the first and second pieces of the sternum; it ascends obliquely towards the right sterno-clavicular articulation, where it divides into the right carotid and right subclavian artery.

Relations.—It is in relation, *in front*, with the left innominate vein, sternum, origin of the sterno-hyoid and sterno-thyroid muscles, remains of the thymus gland, right inferior thyroid veins, and cervical cardiac branch of the pneumogastric; *behind*, with the trachea; to the *right*, with the right innominate vein, right pneumo-

gastric nerve and pleura; to the *left*, with the left common carotid artery and remains of the thymus gland.

Plan of the **Relations** of the Innominate Artery.

Right Side.	*In Front.*	*Left Side.*
	Left brachio-cephalic vein, Sternum, Sterno-hyoid muscle, Sterno-thyroid muscle, Remains of thymus gland, Right inferior thyroid veins, Cervical cardiac branch of pneumogastric.	
Right brachio-cephalic vein, Right pneumogastric nerve, Pleura.	**Innominate Artery.**	Left carotid artery, Remains of thymus gland.
	Behind. Trachea.	

The innominate artery occasionally gives off a small branch, *thyroidea ima* (lowest thyroid), which ascends along the middle of the trachea to the thyroid gland. A knowledge of its existence is important in performing the operation of tracheotomy.

COMMON CAROTID ARTERIES.

The common carotid arteries (*κάρα*, the head) arise, the *right* from the bifurcation of the arteria innominata opposite the right sterno-clavicular articulation, the *left* from the arch of the aorta. It follows, therefore, that the right carotid is shorter than the left; it is also more anterior; and, in consequence of proceeding from a branch instead of from the main trunk, is larger than its fellow.

The **right common carotid artery** (fig. 233, 5) ascends the neck perpendicularly by the side of the trachea and larynx, from behind the right sterno-clavicular articulation to a level with the upper border of the thyroid cartilage, where it divides into the external carotid and internal carotid.

The **left common carotid** (fig. 233, 11) passes somewhat obliquely outwards from the arch of the aorta to the side of the neck, and thence upwards by the side of the trachea and œsophagus to a level with the upper border of the thyroid cartilage, where it divides like the right common carotid into the external carotid and internal carotid.

Relations.—The common carotid artery, in the neck, is enclosed in a fibrous sheath, which also contains the internal jugular vein, lying to the outer side of the artery, and the pneumogastric nerve, which lies between and behind both. The sheath rests on the vertebral column, having interposed the sympathetic nerve and

anterior muscles of the vertebral column, namely, longus colli and rectus anticus major; and being crossed behind by the inferior thyroid artery and recurrent laryngeal nerve. To the *inner side* of the carotid is the trachea, thyroid gland, recurrent laryngeal nerve, inferior thyroid artery, and larynx; to its *outer side*, and enclosed in its sheath, the jugular vein and pneumogastric nerve; and *in front*, the sterno-thyroid, sterno-hyoid, sterno-mastoid, omo-hyoid, and platysma muscles; the superior thyroid, lingual, and facial veins, and the descendens noni nerve. The left common carotid, in addition to the relations just enumerated, which are common to both, is crossed near its commencement by the left brachio-cephalic vein, and supports the remains of the thymus gland: it lies on the trachea; then gets to its side, and is in relation with the œsophagus and thoracic duct: to facilitate the study of these relations, they are here arranged in a tabular form.

Plan of **Relations** of the Common Carotid Artery.

In Front.

Platysma,
Superior thyroid veins,
Lingual and facial veins,
Omo-hyoid,
Sterno-mastoid,
Sterno-hyoid,
Sterno-thyroid,
Descendens noni nerve.

Externally.		*Internally.*
Internal jugular vein, Pneumogastric nerve.	**Common Carotid Artery.**	Trachea, Thyroid gland, Larynx, Recurrent laryngeal nerve, Inferior thyroid artery.

Behind.

Longus colli,
Rectus anticus major,
Sympathetic nerve,
Inferior thyroid artery,
Recurrent laryngeal nerve.

Additional **Relations** of the Left Common Carotid.

In Front.	*Behind.*	*Internally.*	*Externally.*
Left brachio-cephallic vein, Remains of thymus gland, Sternum.	Trachea, Thoracic duct.	Innominate artery, Œsophagus.	Pleura.

no vein closely accompanies this artery

EXTERNAL CAROTID ARTERY.

The external carotid artery ascends nearly perpendicularly from opposite the upper border of the thyroid cartilage, to the space between the neck of the lower jaw and meatus auditorius, where it divides into two terminal branches, temporal and internal maxillary.

Relations.—*In front* it is crossed by the posterior belly of the digastric, stylo-hyoid, and platysma myoides muscles; by the hypoglossal nerve near its origin; higher up it is situated in the substance of the parotid gland, and has in front the facial nerve and temporo-maxillary vein. *Behind*, it is separated from the internal carotid by the stylo-pharyngeus, and stylo-glossus muscle, glosso-pharyngeal nerve, and part of the parotid gland. *Internally*, it has the hyoid bone, pharynx, parotid gland, and ramus of the lower jaw.

Plan of the **Relations** of the External Carotid Artery.

In Front.		*Behind.*
Platysma, Digastric, Stylo-hyoid, Hypoglossal nerve, Facial nerve, Temporo-maxillary vein, Parotid gland.	**External Carotid Artery.**	Stylo-pharyngeus, Stylo-glossus, Glosso-pharyngeal nerve, Parotid gland.
	Internally. Hyoid bone, Pharynx, Parotid gland, Ramus of jaw.	

Branches.—The branches of the external carotid, nine in number, may be arranged into three groups, anterior, posterior, and ascending. They are as follows:—

Anterior.	**Posterior.**
Superior thyroid, Lingual, Facial.	Occipital, Posterior auricular.

Ascending.

Ascending pharyngeal, Parotidean,	Temporal, Internal maxillary.

The **anterior branches** arise from the commencement of the external carotid, within a short distance of each other. The lingual and facial bifurcate, not unfrequently, from a common trunk.

The **SUPERIOR THYROID ARTERY**, the first of the branches of the external carotid, arises from that trunk just below the great cornu of the os hyoides, and curves downwards to the thyroid gland. It is distributed by several large branches to the anterior part of the gland, and anastomoses with its fellow of the opposite side, and with the inferior thyroid arteries. In its course it passes beneath the omo-hyoid, sterno-thyroid, and sterno-hyoid muscles.

Branches.—

Hyoid, Superior laryngeal, Sterno-mastoid.	Inferior laryngeal, Muscular, Glandular.

The **hyoid branch** passes forward beneath the thyro-hyoid muscle, and is distributed to the depressor muscles of the os hyoides near their insertion. It anastomoses with its fellow of the opposite side, and with the hyoid branch of the lingual.

The **superior laryngeal** pierces the thyro-hyoidean membrane, in company with the superior laryngeal nerve, and supplies the mucous membrane and muscles of the larynx, sending a branch upwards to the epiglottis.

The **sterno-mastoid** is commonly a branch of this trunk, although it sometimes comes off directly from the external carotid. It curves downwards and outwards across the carotid sheath to the anterior margin of the sterno-mastoid muscle, to which and to the neighbouring muscles and integument, it is distributed.

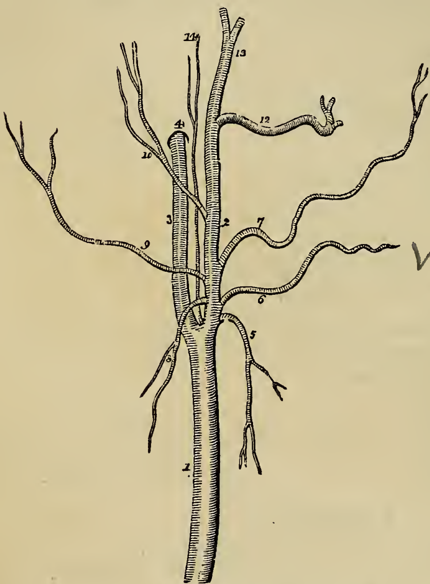


FIG. 234.—Carotid arteries with the branches of the external carotid. 1. Common carotid. 2. External carotid. 3. Internal carotid. 4. Carotid foramen in the petrous portion of the temporal bone. 5. Superior thyroid artery. 6. Lingual artery. 7. Facial artery. 8. Sterno-mastoid artery. 9. Occipital. 10. Posterior auricular. 12. Internal maxillary. 13. Temporal. 14. Ascending pharyngeal artery.

The **inferior laryngeal** or **crico-thyroid** is a small branch which crosses the crico-thyroid membrane along the lower border of the thyroid cartilage. It sends branches through that membrane to supply the mucous lining of the larynx, and inosculates with its fellow of the opposite side.

The **muscular branches** are distributed to the depressor muscles of the os hyoides and larynx.

Numerous **glandular** branches are distributed to the lateral lobes of the thyroid gland, forming a free anastomosis in its substance with the branches of the inferior thyroid.

The **LINGUAL ARTERY** ascends obliquely from its origin; it then passes forwards parallel with the great cornu of the os hyoides; thirdly, it ascends to the under surface of the tongue; and fourthly, runs forward in a serpentine direction to its tip, under the name of *ranine artery*, where it terminates by being distributed to the muscles and mucous membrane of the tongue.

Relations.—The *first* part of its course rests on the middle constrictor muscle of the pharynx, being covered in by the tendon of the digastricus and the stylo-hyoid muscle; the *second* is situated between the middle constrictor and hyo-glossus muscle, the latter separating it from the hypoglossal nerve; in the *third* part of its course it lies between the hyo-glossus and genio-hyo-glossus; and in the fourth (ranine), rests on the lingualis to the tip of the tongue.

Branches.—Hyoid, Dorsalis linguæ, Sublingual, Ranine.

The **hyoid branch** runs along the upper border of the os hyoides, and is distributed to the elevator muscles of the os hyoides near their insertion, inosculating with its fellow of the opposite side, and with the hyoid branch of the superior thyroid when that branch is present.

The **dorsalis linguæ** ascends along the posterior border of the hyo-glossus muscle to the dorsum of the tongue, and is distributed

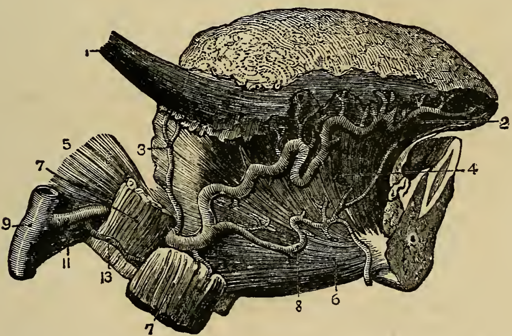


Fig. 235.—Lingual artery and branches. 1. Stylo-glossus muscle. 2. Ranine artery. 3. Dorsalis linguæ artery. 4. Genio-hyo-glossus muscle. 5. Middle constrictor. 6. Genio-hyoid muscle. 7, 7. Hyo-glossus (cut). 8. Sublingual artery. 9. External carotid artery. 11. Lingual artery. 13. Hyoid branch.

to the tongue, fauces, and epiglottis; anastomosing with its fellow of the opposite side.

The **sublingual branch** runs forward on the genio-hyo-glossus muscle, and is distributed to the sublingual gland, mucous membrane of the floor of the mouth, and muscles of the tongue. It is situated between the mylo-hyoid and genio-hyo-glossus, generally accompanies Wharton's duct for a part of its course, and sends a branch to the frænum linguæ. The latter branch affords the considerable hemorrhage which sometimes follows the operation of snipping the frænum in children.

The **ranine artery** may be looked on as the true continuation of the lingual; it runs forwards beneath the tongue, resting upon the lingualis muscle, having the genio-hyo-glossus to its outer side, and covered in by mucous membrane.

It distributes numerous small branches to the substance of the tongue, but does not, as is generally stated, anastomose with its fellow of the opposite side. Hyrtle has proven by experimental injections that there is no communication between the arteries of the two sides, and this fact is substantiated by the experience of surgeons, who find that the longitudinal section of the tongue in the middle line is unaccompanied by arterial hemorrhage.

FACIAL ARTERY. — The facial artery (maxillaris externa) arises immediately above the lingual and a little above the great cornu of the os hyoides, and passes forwards to the submaxillary gland, in which it lies embedded. It then curves around the body of the lower jaw, close to the anterior inferior angle of the masseter muscle, ascends to the angle of the mouth, and thence to the angle of the eye, where it is named, *angular artery*. The facial artery is tortuous in its course over the buccinator muscle to accommodate itself to the movements of the jaw.

Relations.—Below the jaw it passes beneath the digastricus and stylo-hyoid muscle ; on the body of the lower jaw it is covered by the platysma myoides, and at the angle of the mouth by the depressor anguli oris and zygomatic muscles. It rests on the submaxillary gland, lower jaw, buccinator, orbicularis oris, levator anguli oris, levator labii superioris proprius, and levator labii superioris alæque nasi.

Its *branches* may be grouped into those which are given off below the jaw, and those on the face ; they may be thus arranged :—

Below the Jaw.	**On the Face.**
Ascending palatine,	Buccal,
Tonsillar,	Inferior labial,
Submaxillary,	Inferior coronary,
Submental,	Superior coronary,
Muscular.	Lateral nasal,
	Angular.

The **inferior** or **ascending palatine** branch ascends between the stylo-glossus and stylo-pharyngeus muscle, to be distributed to the tonsil and soft palate, and anastomoses with the descending palatine branch of the internal maxillary artery.

The **tonsillar** branch ascends by the side of the pharynx, and pierces the superior constrictor muscle to be distributed to the tonsil.

The **submaxillary** are four or five branches which supply the submaxillary gland.

The **submental** branch runs forward on the mylo-hyoid muscle, under cover of the body of the lower jaw, distributes branches to the submaxillary gland, and muscles attached to the lower jaw, and anastomoses with branches of the sublingual and inferior dental artery.

The **muscular** branches are distributed to the masseter, internal pterygoid, digastric, and stylo-hyoid.

The **buccal** branches, eight or ten in number, are given off upon

the face, and are distributed to the buccinator, masseter, muscles of the upper lip, orbicularis palpebrarum, and integument of the cheek. They anastomose with the buccal branch of the internal maxillary, the transverse facial, and infraorbital.

The **inferior labial** branch passes forward beneath the depressor anguli oris muscle, and is distributed to the muscles of the lower lip, inosculating with the labial branch of the inferior dental, the inferior coronary, and submental.

The **inferior coronary** branch is given off at the angle of the mouth, and passes inwards near the edge of the lower lip, lying between the orbicularis and mucous membrane: it inosculates with its fellow of the opposite side.

The **superior coronary** branch, arising close to, or in common with, the preceding, takes its course in the same manner along the upper lip, inosculating with its fellow of the opposite side. At the middle of the lip it sends a small branch upwards to the septum of the nose (arteria septi).

The **lateral nasal** branch is given off near the ala nasi, and passes beneath the levator labii superioris alæque nasi, to be distributed to the nose. It inosculates with the nasal branch of the ophthalmic artery and the infraorbital.

The **angular** is the termination of the facial artery; it inosculates at the inner side of the orbit with the termination of the ophthalmic artery.

The **inosculations** of the facial artery are numerous—namely, with the sublingual branch of the lingual, ascending pharyngeal artery, descending palatine artery, inferior dental at its escape from the mental foramen, infraorbital at the infraorbital foramen, buccal branches of the internal maxillary on the surface of the buccinator, transverse facial on the side of the face, and nasal and frontal branches of the ophthalmic artery at the angle of the eye.

The facial artery is subject to variety in length: it not unfrequently terminates at the angle of the nose or mouth, and is rarely symmetrical on both sides of the face.

The **OCCIPITAL ARTERY**, smaller than the anterior branches, passes backwards behind the parotid gland and beneath the posterior belly of the digastric, trachelo-mastoid, and sterno-mastoid to the occipital groove in the mastoid portion of the temporal bone. It then ascends between the splenius and complexus, pierces the trapezius, and is distributed to the back of the head, anastomosing with the opposite occipital, posterior auricular, and temporal artery. The hypoglossal nerve curves around this artery opposite the angle of the jaw and near its origin from the external carotid. The occipital artery is sometimes derived from the ascending cervical of the thyroid axis, or from the internal carotid.

Branches.—It gives off several muscular branches to the sterno-mastoid, digastric, stylo-hyoid, and deep muscles in its course, a small branch to the external ear, and two larger branches, inferior meningeal and princeps cervicis.

The **inferior meningeal** ascends by the side of the internal jugular vein, and passes through the jugular foramen, to be distributed to the dura mater.

The **arteria princeps cervicis** is a large and irregular branch. It descends the neck between the complexus and semi-spinalis colli, and inosculates with the cervicalis profunda of the subclavian and with branches of the vertebral. This branch is the means of establishing an important collateral circulation between the branches of the carotid and subclavian, after ligature of the common carotid artery.

A small **mastoid** branch enters the skull through the mastoid foramen, and is distributed to the dura mater.

The **POSTERIOR AURICULAR ARTERY** arises from the external carotid, above the level of the digastric and stylo-hyoid muscles, and ascends by the side of the styloid process and behind the parotid gland, to the back part of the concha. It is distributed by two branches to the external ear, **auricular** branch, and side of the head, **occipital** branch, anastomosing with the occipital and temporal artery; some of its branches pass through fissures in the fibro-cartilage to reach the anterior surface of the pinna. The anterior auricular arteries are branches of the temporal.

Branches.—The posterior auricular gives off a branch to the digastric muscle, and several branches to the parotid gland; it then gives off the **stylo-mastoid,** which enters the stylo-mastoid foramen to be distributed to the aquæductus Fallopii, labyrinth, mastoid cells, and tympanum; a twig accompanies the chorda tympani under the name of tympanica superior. One branch of the stylo-mastoid artery forms with the anterior tympanic artery an anastomotic circle round the drum of the ear.

The **ASCENDING PHARYNGEAL ARTERY,** the smallest of the branches of the external carotid, arises from that trunk near its origin (or at the point of bifurcation of the common carotid), and ascends between the internal carotid and side of the pharynx to the base of the skull, where it divides into two branches: **meningeal,** which enters the jugular or anterior condylar foramen to be distributed to the dura mater; and **pharyngeal.** It supplies the pharynx, tonsils, soft palate, and Eustachian tube.

The **PAROTIDEAN ARTERIES** are four or five large branches which are given off from the external carotid whilst in the parotid gland. They are distributed to the structure of the gland, their terminal branches reaching the integument of the side of the face, and masseter muscle.

The **TEMPORAL ARTERY** is one of the two terminal branches of the external carotid. It ascends over the root of the zygoma; and, at about an inch and a half above the zygomatic arch, divides into an anterior and posterior temporal branch. The **anterior temporal** is distributed over the front of the temple and arch of the skull, and anastomoses with the opposite anterior temporal, and with the supraorbital and frontal artery. The **posterior tem-**

poral curves upwards and backwards, and inosculates with its fellow of the opposite side, with the posterior auricular and occipital artery.

The trunk of the temporal artery is covered by the parotid gland and attrahens auriculam muscle, and rests on the temporal fascia.

The **branches** of the temporal artery are—some small offsets to the parotid gland and articulation of the lower jaw, and the following :—

Anterior auricular, Transverse facial,
Middle temporal. anterior auricular

The **anterior auricular branches,** two in number, are distributed to the anterior portion of the pinna.

The **transverse facial** arises from the temporal immediately below the zygoma, and runs transversely across the face, resting on the masseter muscle, and lying parallel with and a little above Stenson's duct. It anastomoses with the facial and infraorbital artery.

The **middle temporal branch** passes through an opening in the temporal fascia immediately above the zygoma into the substance of the temporal muscle, and sends small branches to that muscle, inosculating with the deep temporal arteries. It gives off a small **orbital branch** which passes forward immediately above the zygoma, between the two layers of the temporal fascia, and inosculates beneath the orbicularis palpebrarum, with the lachrymal branch of the ophthalmic artery.

The **INTERNAL MAXILLARY ARTERY,** the other terminal branch of the external carotid, has next to be examined.

Dissection.—The internal maxillary artery passes inwards behind the neck of the lower jaw to the deep structures in the face ; we require, therefore, to remove several parts for the purpose of seeing it completely. To obtain a good view of the vessel, the zygoma should be sawn across in front of the external ear, and the malar bone near the orbit. Turn down the zygomatic arch with the masseter muscle. In doing this, a small artery and nerve will be seen crossing the sigmoid notch of the lower jaw to enter the masseter muscle (masseteric). Saw through the ramus of the jaw on a level with the crowns of the molar teeth, and divide the neck of the condyle with cutting forceps, then turn the coronoid process with the insertion of the temporal muscle upwards towards the skull ; some vessels will be seen entering the under surface of the muscle ; these are the *deep temporal.* If the artery lies beneath the external pterygoid muscle, it will be necessary to disarticulate the condyle of the jaw and turn it inwards, together with the muscle itself. The artery and the deep branches of the inferior maxillary nerve will be seen lying against the internal pterygoid muscle. These are to be carefully freed from fat and cellular tissue, and then examined.

The internal maxillary artery commences in the substance of the parotid gland, opposite the meatus auditorius externus ; it passes in the first instance horizontally forward behind the neck of the lower

jaw; next, curves around the lower border of the external pterygoid muscle near its insertion, and ascends obliquely forwards upon the outer side of that muscle; it then passes inwards between the two heads of the external pterygoid, and enters the spheno-maxillary fossa. Occasionally it takes its course between the two pterygoid muscles, without appearing on the outer surface of the external pterygoid. For the purposes of description it admits of division into three portions: maxillary, pterygoid, and spheno-maxillary.

Relations.—The *maxillary* portion is situated between the neck of the jaw and the internal lateral ligament and inferior dental nerve, and lies parallel with the auriculo-temporal nerve; the *pterygoid* portion between the external pterygoid muscle, and the masseter and temporal muscle. The *spheno-maxillary* portion lies between the two heads of the external pterygoid muscle, and, in the spheno-maxillary fossa, is in relation with Meckel's ganglion.

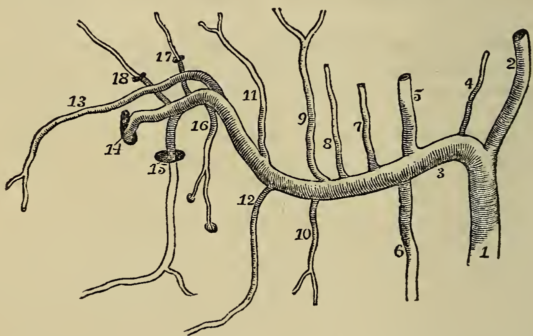


FIG. 236.—Diagram of the branches of the internal maxillary artery. 1. External carotid. 2. Superficial temporal. 3. Internal maxillary. 4. Anterior tympanic. 5. Middle meningeal. 6. Inferior dental. 7. Lesser meningeal. 8. Masseteric. 9. Posterior temporal. 10. Pterygoid. 11. Anterior temporal. 12. Buccal. 13. Infraorbital. 14. Spheno-palatine. 15. Descending palatine. 16. Superior dental. 17. Vidian. 18. Pterygo-palatine.

Branches.—*Maxillary Portion.*

Anterior tympanic,
Inferior dental,
Middle meningeal,
Lesser meningeal,

Pterygoid Portion.

Deep temporal,
Pterygoid,
Masseteric,
Buccal.

Spheno-maxillary Portion.

Superior dental,
Infra-orbital,
Pterygo-palatine,
Spheno-palatine,
Superior palatine,
Vidian.

The **anterior tympanic** branch passes into the tympanum through the fissure of Glaser, and is distributed to the laxator

tympani, and membrana tympani; on the latter it inosculates with the stylo-mastoid, a branch of the posterior auricular artery, and with the Vidian artery.

The **inferior dental** descends to the dental foramen, and enters the canal of the lower jaw in company with the inferior dental nerve. Opposite the bicuspid teeth it divides into two branches, one of which is continued onwards within the bone as far as the symphysis, to supply the incisor teeth; while the other, *mental*, escapes with the nerve at the mental foramen, and anastomoses with the inferior labial and submental branch of the facial. It supplies the alveoli and teeth of the lower jaw, sending small branches along the canals in their roots. At the inferior dental foramen, it gives off a *mylo-hyoid* branch, which accompanies the mylo-hyoid nerve.

The **middle meningeal** is embraced at its origin by the two roots of the auriculo-temporal nerve; it ascends behind the temporo-maxillary articulation to the foramen spinosum in the spinous process of the sphenoid bone, and entering the cranium, divides into an anterior and a posterior branch. The *anterior branch* crosses the great ala of the sphenoid to the groove or canal in the anterior inferior angle of the parietal bone, and divides into branches which ramify on the external surface of the dura mater, and anastomose with corresponding branches from the opposite side. The *posterior branch* crosses the squamous portion of the temporal bone, to the posterior part of the dura mater and cranium.

The branches of the middle meningeal artery are distributed chiefly to the bones of the skull; in the middle fossa it sends a small petrosal branch through the hiatus Fallopii to the facial nerve, and branches to the Gasserian ganglion.

The **lesser meningeal** is a small branch which ascends to the foramen ovale, and passes into the skull to be distributed to the Gasserian ganglion and dura mater. It gives off a twig to the nasal fossæ and soft palate.

The lesser meningeal is often derived from the middle, instead of from the internal maxillary directly;—the tympanic also occasionally springs from the same trunk.

The **muscular branches** are distributed, as their names imply, to the five muscles of the maxillary region; the *deep temporal* branches are two in number, anterior and posterior; they inosculate with the middle temporal. The *pterygoid* branches are distributed to the two muscles of that name. The *masseteric* artery passes outwards, behind the tendon of the temporal muscle and over the sigmoid notch, to the masseter muscle. The *buccal* branch, arising opposite the anterior part of the pterygoid muscle, passes downwards with the buccal nerve to the buccinator muscle. It inosculates with the facial and transverse facial artery.

The **superior dental** or **alveolar artery** is given off from the internal maxillary, just as that vessel is about to make its turn inwards to reach the spheno-maxillary fossa. It descends on the tuberosity of the superior maxillary bone, and sends its branches

through several small foramina to supply the posterior teeth of the upper jaw and the antrum. The terminal branches are continued forwards on the alveolar process, to be distributed to the gums and sockets of the teeth.

The **infraorbital** appears, from its size, to be the proper continuation of the artery. It runs along the infraorbital canal with the superior maxillary nerve, sending branches upwards into the orbit, and downwards, through canals in the bone, to supply the mucous membrane of the antrum and the teeth of the upper jaw, and emerges on the face at the infraorbital foramen. The branch which supplies the incisor teeth is the *anterior dental artery;* on the face the infraorbital inosculates with the facial and transverse facial artery.

The **pterygo-palatine** is a small branch which passes backwards through the pterygo-palatine canal, and supplies the mucous membrane of the posterior part of the nares, upper part of the pharynx, Eustachian tube, and sphenoidal cells.

The **spheno-palatine**, or posterior nasal, enters the superior meatus of the nose through the spheno-palatine foramen, in company with the nasal filaments of Meckel's ganglion, and divides into two branches; one branch, *arteria septi*, is distributed to the mucous membrane of the septum, and inosculates in the anterior palatine canal with the terminal branch of the descending palatine; the other supplies the mucous membrane of the lateral wall of the nares, antrum, and sphenoid and ethmoid cells.

The **superior** or **descending palatine artery** descends along the posterior palatine canal, in company with the palatine branches of Meckel's ganglion, to the posterior palatine foramen; it then bends forward, lying in a groove of the bone, and is distributed to the palate. While in the posterior palatine canal it sends several twigs backwards through the small posterior palatine foramina to supply the soft palate; anteriorly it gives off a branch, *anterior palatine*, which reaches the nares through the anterior palatine canal, and inosculates with the arteria septi.

The **Vidian** or **pterygoid** branch passes backwards along the pterygoid canal with the nerve of the same name, and is distributed to the sheath of the nerve, the Eustachian tube, and mucous membrane of the upper part of the pharynx.

INTERNAL CAROTID ARTERY.

The internal carotid artery curves slightly outwards from the bifurcation of the common carotid, and ascends nearly perpendicularly by the side of the pharynx, to the carotid foramen in the petrous portion of the temporal bone. It next passes *inwards*, along the carotid canal, *forwards* by the side of the sella turcica, and *upwards* by the anterior clinoid process, where it pierces the dura mater, and divides into three terminal branches. The course of this artery is remarkable for the number of angular curves which it

forms; one or two of these flexures are sometimes seen in the cervical portion, near the base of the skull; and, by the side of the sella turcica, it resembles the italic letter *s*, placed horizontally.

Relations.—In consideration of its connections, the artery is divisible into a cervical, petrous, cavernous, and cerebral portion. The *cervical portion* is in relation *posteriorly* with the rectus anticus major, superior cervical ganglion of the sympathetic, and pharyngeal and superior laryngeal nerve which cross behind it. *Internally* it is in relation with the side of the pharynx, tonsil, and ascending pharyngeal artery. *Externally* with the internal jugular vein, glosso-pharyngeal, pneumogastric, and hypoglossal nerve; and *in front* with the stylo-glossus and stylo-pharyngeus muscle, stylo-hyoid ligament, glosso-pharyngeal nerve, and parotid gland.

Plan of the **Relations** of the *Cervical Portion* of the Internal Carotid Artery.

	In Front. Parotid gland, Stylo-glossus, Stylo-pharyngeus, Stylo-hyoid ligament, Glosso-pharyngeal nerve.	
Internally. Pharynx, Tonsil, Ascending pharyngeal artery.	**Internal Carotid Artery.**	*Externally.* Internal jugular vein, Glosso-pharyngeal, Pneumogastric, Hypoglossal nerve.
	Behind. Pharyngeal nerve, Superior laryngeal nerve, Superior cervical ganglion, Rectus anticus major.	

The PETROUS PORTION is separated from the bony wall of the carotid canal by a periosteal lining derived from the dura mater; it is in relation with the carotid plexus, and is covered in by the Gasserian ganglion.

The CAVERNOUS PORTION is situated in the cavernous sinus, and is in relation by its outer side with the lining membrane of the sinus and with the sixth nerve.

The CEREBRAL PORTION of the artery is enclosed in a sheath of the arachnoid, and is in relation with the optic nerve. At its point of division it is situated in the fissure of Sylvius.

Branches.—The cervical portion of the internal carotid gives off no branches: from the other portions are derived the following:—

Tympanic,	Anterior cerebral,
Arteriæ receptaculi,	Middle cerebral,
Ophthalmic,	Posterior communicating,

Anterior choroid.

The **tympanic** is a small branch given off in the carotid canal; it enters the tympanum and inosculates with the tympanic branch of the internal maxillary, and with the stylo-mastoid artery.

The **arteriæ receptaculi** *anterior* and *posterior* are two small branches given off in the cavernous sinus and distributed to the parts contained in the sinus, to the Gasserian ganglion, and dura mater; one of the twigs distributed to the latter is the *anterior meningeal artery.*

The **ophthalmic artery** arises from the internal carotid, just as that vessel pierces the dura mater, and enters the orbit through the optic foramen, lying externally to the optic nerve. It then crosses the optic nerve to the inner wall of the orbit; and runs along the lower border of the superior oblique muscle, to the inner angle of the eye, where it divides into two terminal branches, frontal and nasal.

Branches.—The branches of the ophthalmic artery, ten in number, may be arranged into two groups: first, those distributed to the orbit and surrounding parts; and, secondly, those which supply the muscles and globe of the eye. They are—

First Group.	Second Group.
Lachrymal,	Muscular,—anterior ciliary,
Supraorbital,	Ciliary short and long,
Posterior ethmoidal,	Arteria centralis retinæ.
Anterior ethmoidal,	
Palpebral,	
Frontal,	
Nasal.	

The **lachrymal** is the first branch of the ophthalmic artery, and is usually given off immediately before that artery enters the optic foramen. It follows the course of the lachrymal nerve, above the upper border of the external rectus muscle, and is distributed to the lachrymal gland. The small branches which escape from the gland supply the conjunctiva and upper eyelid. The lachrymal artery gives off a *malar branch* which passes through the malar bone into the temporal fossa, and inosculates with the deep temporal arteries, while some of its branches become subcutaneous on the cheek, and anastomose with the transverse facial.

The **supraorbital artery** follows the course of the frontal nerve, resting on the levator palpebræ muscle; it passes through the supraorbital foramen, and divides into a superficial and deep branch, which are distributed to the muscles and integument of the forehead, and to the pericranium. At the supraorbital foramen it sends a branch inwards to the diploë.

The **ethmoidal arteries** *posterior* and *anterior* pass through the ethmoidal foramina, and are distributed to the falx cerebri and to the ethmoidal cells and nasal fossæ. The latter accompanies the nasal nerve, and sends a branch to the frontal sinus. The branches distributed to the dura mater are called *anterior meningeal.*

The **palpebral arteries** *superior* and *inferior* are given off from

the ophthalmic, near the inner angle of the orbit; they encircle the eyelids, forming a superior and an inferior arch near the borders of the lids, between the orbicularis palpebrarum and tarsal cartilage. At the outer angle of the eyelids, the superior palpebral inosculates with the orbital branch of the temporal artery. The inferior palpebral artery sends a branch to the caruncula lachrymalis and lachrymal sac.

The **frontal artery**, one of the terminal branches of the ophthalmic, emerges from the orbit at its inner angle, and ascends along the middle of the forehead. It is distributed to the integument, muscles, and pericranium, and anastomoses with the supraorbital artery.

The **nasal artery**, the other terminal branch of the ophthalmic, passes out of the orbit above the tendo oculi, and divides into two branches; one of which inosculates with the angular artery, while the other, *dorsalis nasi*, runs along the ridge of the nose, and is distributed to the integument of that organ. The nasal artery sends a small branch to the lachrymal sac.

The **muscular branches**, usually two in number, *superior* and *inferior*, supply the muscles of the orbit; and at the anterior part of the globe of the eye give off the *anterior ciliary* arteries which pierce the sclerotic near its margin of connection with the cornea, and are distributed to the iris. It is the congestion of these vessels that gives rise to the vascular zone around the cornea in iritis.

The **ciliary arteries** are divisible into three groups, short, long, and anterior.

The **short ciliary**, from ten to fifteen in number, pierce the sclerotic around the entrance to the optic nerve, and supply the choroid coat and ciliary processes. The *long ciliary*, two in number, pierce the sclerotic at opposite sides of the globe of the eye, and pass forwards between it and the choroid to the iris. They form an arterial circle around the circumference of the iris by inosculating with each other, and from this circle branches are given off which ramify in the substance of the iris, and form a second circle around the pupil. The *anterior ciliary*, six to twelve in number, are branches of the muscular arteries; they terminate in the great arterial circle of the iris.

The **arteria centralis retinæ** pierces the optic nerve obliquely, about a quarter of an inch from the globe of the eye, and passes forwards in the centre of its cylinder to the retina, where it divides into branches, which ramify in the inner layer of that membrane. It supplies the retina and hyaloid membrane. In the fœtus a small branch of this artery is seen to run through the centre of the vitreous humour to the posterior surface of the lens; it is, however, commonly absent in the adult.

The **anterior cerebral artery** passes forwards in the great longitudinal fissure between the two hemispheres of the brain; then curves backwards along the corpus callosum to its posterior extremity. The two anterior cerebral arteries are connected soon after their origin by a short anastomosing trunk, the *anterior communicating artery*.

The **middle cerebral artery** (Sylvian artery), larger than the

preceding, passes outwards along the fissure of Sylvius, and divides into branches, which supply the anterior and middle lobes of the brain, and the island of Reil.

The **posterior communicating artery**, variable in size, sometimes double, and sometimes altogether wanting, passes backwards and inosculates with the posterior cerebral, a branch of the basilar artery. Occasionally it is so large as to take the place of the posterior cerebral artery.

The **anterior choroid** is a small branch which is given off from the internal carotid, near the origin of the posterior communicating artery, and passes beneath the edge of the middle lobe of the brain to enter the descending cornu of the lateral ventricle. It is distributed to the choroid plexus, and to the walls of the middle cornu.

A more minute description of the arteries of the brain, their communications and distribution, will be given along with the descriptive anatomy of that organ in Part VI. of this work.

SUBCLAVIAN ARTERY.

The subclavian artery on the right side arises from the innominate artery, opposite the sterno-clavicular articulation; on the left, from the arch of the aorta. The right is consequently shorter than the left, and situated nearer the anterior wall of the chest; it is also somewhat greater in diameter, from being a branch of a branch, in place of a division from the main trunk.

The course of the subclavian artery is divisible, for the sake of precision and surgical observation, into three portions. The first portion of the right and left arteries differs in its course and relations in correspondence with the dissimilarity of origin above referred to. The other two portions are alike on both sides.

The *first portion*, on the *right side*, ascends obliquely outwards to the inner border of the scalenus anticus. On the *left side* it ascends perpendicularly to the inner border of that muscle. The *second portion* curves outwards behind the scalenus anticus; the *third portion* passes downwards and outwards beneath the clavicle, to the lower border of the first rib, where it becomes the axillary artery.

Relations.—The *first portion*, on the *right side*, is in relation, in *front*, with the sterno-mastoid (clavicular portion), origin of sterno-hyoid and sterno-thyroid, internal jugular and vertebral vein, and is crossed by the pneumogastric nerve, phrenic nerve, and cardiac branches of the sympathetic. *Behind* and *beneath* it is invested by the pleura, is crossed by the right recurrent laryngeal nerve, and is in relation farther back with the sympathetic nerve, longus colli muscle, and transverse process of the seventh cervical vertebra. The *first portion* on the *left side* is in relation in front with the pleura, internal jugular vein, vena innominata, and pneumogastric, cardiac and phrenic nerve (which lie nearly parallel to it). To its *inner side* is the left carotid artery, trachea, œsophagus, and thoracic duct; to its *outer side* the pleura; and *behind*, the œsophagus, thoracic duct,

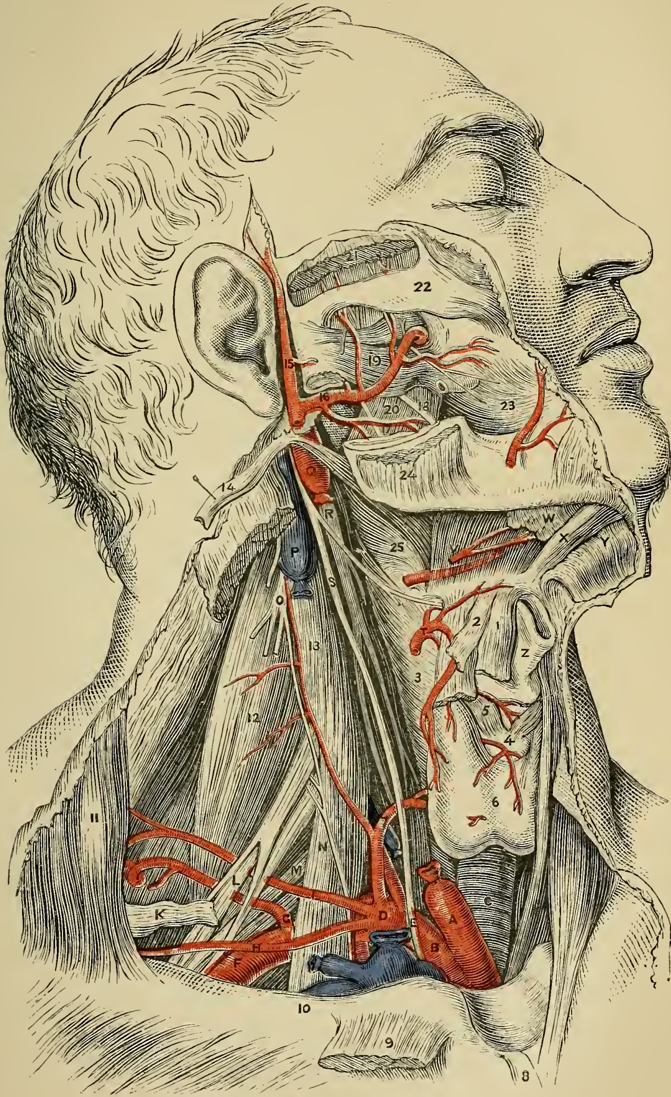
branch of Subclavian
Vertebral artery enters the
6th Cervical vertebra at transverse
process & then comes out by
a sharp turn thro, the vertebral
foramen of 1st vertebra - then it
enters the skull & with the
Vertebral artery of opposite
side terminates in the
at lower border of Pons
Basilar artery and this lies
on the basilar process
of the Occipital bone -

PLATE 22.

DEEP DISSECTION OF HEAD AND NECK.

A. Right common carotid (cut).
B. Right subclavian.
C. Trachea.
D. Thyroid axis.
E. Vagus nerve, crossing subclavian artery.
F. Subclavian artery, third part.
G. Posterior scapular artery, arising from subclavian.
H. Transversalis humeri artery.
I. Transversalis colli artery.
K. Posterior belly of omo-hyoid.
L. Median nerve, branch of brachial plexus.
M. Brachial plexus.
N. Scalenus anticus.
O. Cervical plexus.
P. Upper part of internal jugular vein.
Q. Upper part of internal carotid artery.
R. Superior cervical ganglion of sympathetic.
S. Upper part of pneumo-gastric nerve.
T. Superior thyroid artery.
V. Hyo-glossus muscle covering lingual artery.
W. Sublingual gland.
X. Genio-hyoid muscle.
Y. Mylo-hyoid muscle (turned down).
Z. Thyroid cartilage.
1. Sterno-hyoid muscle.
2. Omo-hyoid muscle.
3. Inferior constrictor of pharynx.
4. Cricoid cartilage.
5. Crico-thyroid muscle.
6. Thyroid body.
7. Inferior thyroid artery.
8. Sternal origin of sterno-mastoid.
9. Clavicular origin of sterno-mastoid.
10. Clavicle.
11. Trapezius.
12. Scalenus posticus.
13. Rectus capitis anticus major.
14. Stylo-hyoid (turned back).
15. Temporal artery.
16. Internal maxillary artery.
17. Inferior dental nerve.
18. Lingual branch of 5th nerve.
19. Pterygoideus externus.
20. Pterygoideus internus.
21. Temporal muscle (cut).
22. Zygomatic arch.
23. Buccinator.
24. Masseter.
25. Middle constrictor of pharynx.

PLATE 22.



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inferior cervical ganglion of the sympathetic, longus colli, and vertebral column.

Plan of the **Relations** of the *First Portion* of the *Right* Subclavian Artery.

In Front.		*Behind and Beneath.*
Clavicular part of sterno-mastoid, Sterno-hyoid, Sterno-thyroid, Internal jugular vein, Vertebral vein, Pneumogastric nerve, Phrenic nerve, Cardiac nerves.	**Right Subclavian Artery.**	Pleura, Recurrent nerve, Sympathetic nerve, Longus colli muscle, Transverse process of 7th cervical vertebra.

Plan of the **Relations** of the *First Portion* of the *Left* Subclavian Artery.

	In Front. Pleura, Internal jugular vein, Vena innominata, Pneumogastric nerve, Cardiac nerves, Phrenic nerve.	
Inner Side. Left carotid artery, Trachea, Œsophagus, Thoracic duct.	**Left Subclavian Artery.**	*Outer Side.* Pleura.
	Behind. Œsophagus, Thoracic duct, Inferior cervical ganglion, Longus colli, Vertebral column.	

The *second portion* of the artery has the platysma, sterno-mastoid, and scalenus anticus *in front*; the scalenus medius and first dorsal nerve *behind*; the upper nerves of the plexus *above*, and the pleura *below*. The scalenus anticus separates it from the phrenic nerve and subclavian vein, which latter is rather below the level of the artery.

Plan of the **Relations** of the *Second Portion* of the Subclavian Artery.

	In Front. Platysma, Sterno-mastoid, Scalenus anticus.	
Above. Brachial plexus.	**Subclavian Artery.** *Second Portion.*	*Below.* Pleura.
	Behind. Scalenus medius, First dorsal nerve.	

The *third portion* of the artery is situated in the subclavian triangle, and is more superficial than the rest. In *front* it is covered by the integument, platysma, and deep fascia, and crossed by the supraclavicular nerves, and external jugular vein. Lower down it is crossed by the suprascapular artery and vein, and gets behind the subclavius muscle and clavicle. *Behind*, it has the scalenus medius; *above*, the brachial plexus; and *below*, the first rib and subclavian vein.

Plan of the **Relations** of the *Third Portion* of the Subclavian Artery.

	Above. Brachial plexus.	
In Front. Integument, Platysma, External jugular vein, Deep fascia, Supraclavicular nerves, Suprascapular vessels, Clavicle, Subclavius.	**Subclavian Artery.** *Third Portion.*	*Behind.* Scalenus medius.
	Below. First rib, Subclavian vein.	

Branches.—The branches of the subclavian artery are four, and sometimes five in number. Three are given off by the *first portion* of the artery; one, the superior intercostal, by the *second portion;* when a fifth artery exists, it arises from the third portion, and is the posterior scapular. So frequent is the occurrence of this variation, that many anatomists consider it to be the normal condition. In a tabular form the branches are as follows:—

Vertebral,
Internal mammary,
Thyroid axis, { Inferior thyroid, Suprascapular, or transversalis humeri, Transversalis colli.
Superior intercostal,—Cervicalis profunda.

The **VERTEBRAL ARTERY**, the first and largest of the branches of the subclavian artery, arises from the posterior aspect of that trunk; it ascends through the foramina in the transverse processes of all the cervical vertebræ, excepting the last; then winds backwards around the articulating process of the atlas; and, piercing the dura mater, enters the skull through the foramen magnum. The two arteries unite at the lower border of the pons Varolii, to form the *basilar artery*. At its origin the artery is behind the internal jugular vein, and as it ascends comes to be placed between the scalenus anticus and longus colli muscles. In the foramina of the transverse processes of the vertebræ the artery lies in front of the cervical nerves, and has the vertebral vein in front of it; on the left side, it

is crossed by the thoracic duct. The sub-occipital nerve passes out beneath it where it lies on the groove of the atlas. If the vertebral arteries differ in size, the left is generally the larger of the two.

The **BASILAR ARTERY** formed by the union of the two vertebrals is so named from its position at the base of the brain ; it runs forward in the groove on the midline of the pons Varolii, and at the anterior border of the pons divides into four terminal branches, two to each side.

Branches.—The branches of the vertebral artery are the following :—

Lateral spinal,	Anterior spinal,
Muscular,	Posterior spinal,
Posterior meningeal,	Inferior cerebellar.

The **lateral spinal branches** enter the intervertebral foramina, and taking the course of the roots of the spinal nerves, are distributed to the spinal cord and vertebræ.

The **muscular branches** are distributed to the deep muscles of the neck, as the vertebral artery curves round the articular process of the atlas ; they anastomose with the deep cervical and occipital arteries.

The **posterior meningeal** are one or two small branches which enter the cranium through the foramen magnum, to be distributed to the dura mater of the cerebellar fossæ, and to the falx cerebelli.

The **anterior spinal** is a small branch which unites with its fellow of the opposite side on the front of the medulla oblongata. The artery formed by the union of these two vessels descends along the anterior aspect of the spinal cord, to which it distributes branches.

The **posterior spinal** winds around the medulla oblongata to the posterior aspect of the cord, and descends on each side to the cauda equina. It communicates very freely with the spinal branches of the intercostal and lumbar arteries, and near its origin sends a branch upwards to the fourth ventricle.

The **inferior cerebellar arteries** wind around the upper part of the medulla oblongata to the under surface of the cerebellum, to which they are distributed. They pass between the filaments of origin of the hypoglossal nerve in their course, and anastomose with the superior cerebellar arteries.

The branches of the basilar artery are :—

Transverse,	Superior cerebellar,	Posterior cerebral.

The **transverse** branches of the basilar artery supply the pons Varolii and adjacent parts of the brain. One of these branches, larger than the rest, receives the name of *anterior inferior cerebellar* artery ; it passes along the crus cerebelli to be distributed to the anterior border of the cerebellum, and anastomoses with the inferior cerebellar of the vertebral. This artery gives off a small branch,

auditory artery, which accompanies the facial and auditory nerves into the meatus auditorius internus; it may be derived directly from the basilar.

The **superior cerebellar arteries**, two of the terminal branches of the basilar, wind around the crus cerebri on each side, lying in relation with the fourth nerve, and are distributed to the upper surface of the cerebellum, inosculating with the inferior cerebellar.

The **posterior cerebral arteries**, the other two terminal branches of the basilar, wind around the crus cerebri at each side, and are distributed to the posterior lobes of the cerebrum. They are separated from the superior cerebellar arteries near their origin, by the third pair of nerves, and are in close relation with the fourth pair

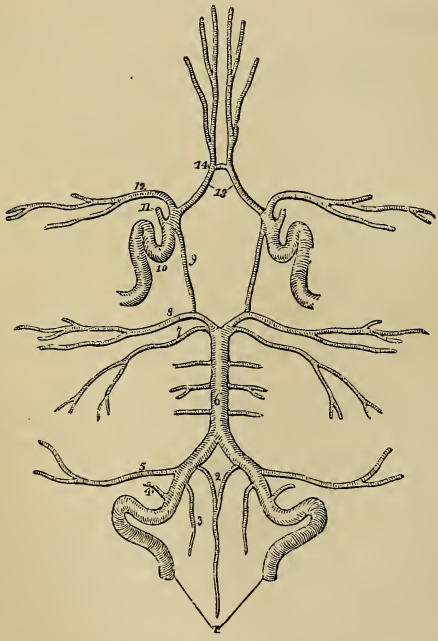


FIG. 237.—Circle of Willis. The arteries being symmetrical have references on one side only. 1. Vertebral arteries. 2. Anterior spinal branches uniting to form a single vessel. 3. Posterior spinal artery. 4. Posterior meningeal. 5. Inferior cerebellar. 6. Basilar artery giving off transverse branches. 7. Superior cerebellar artery. 8. Posterior cerebral. 9. Posterior communicating branch of the internal carotid. 10. Internal carotid artery, showing its curves within the skull. 11. Ophthalmic artery divided across. 12. Middle cerebral artery. 13. Anterior cerebral arteries, connected by, 14, Anterior communicating artery.

in their course around the crura cerebri. Anteriorly, near their origin, they give off a tuft of small vessels which enter the locus perforatus, and they receive the posterior communicating arteries from the internal carotid. They also send a branch called *posterior choroid*, to the velum interpositum and choroid plexus.

The communications established between the anterior cerebral arteries in front, and the internal carotids and posterior cerebral arteries behind, by the communicating arteries, constitute the **circle**

of Willis. This remarkable vascular communication at the base of the brain is formed by the anterior communicating branch, anterior cerebrals, and internal carotid arteries in front, and by the posterior communicating, posterior cerebrals, and basilar artery behind.

A more full description of the arteries of the brain will be found in Part VI.

The **INTERNAL MAMMARY ARTERY** arises from the under side of the subclavian, and passes down behind the subclavian vein to the cartilage of the first rib. It then descends by the side of the sternum, resting on the cartilages of the ribs, to the level of the sixth intercostal space, where it divides into two terminal branches, superior epigastric and musculo-phrenic. At its origin the artery is covered by the internal jugular and subclavian veins, and as it enters the chest it is crossed by the phrenic nerve; it then gets under cover of the pleura, and lower down lies between the triangularis sterni and internal intercostal muscles.

The **branches** of the internal mammary are—

Comes nervi phrenici,	Anterior intercostal,
Mediastinal,	Perforating,
Pericardiac,	Musculo-phrenic,
Superior epigastric.	

The **comes nervi phrenici** (superior phrenic), a long and slender branch given off by the artery as it enters the chest, descends with the phrenic nerve between the pleura and pericardium to the diaphragm, to which it is distributed, inosculating with the musculo-phrenic and abdominal phrenic arteries.

The **mediastinal** and **pericardiac** branches are small vessels distributed to the anterior mediastinum, pericardium, and thymus gland (*thymic*). Some *sternal* branches are sent to supply the sternum and triangularis sterni muscle.

The **anterior intercostals** supply the intercostal muscles of the front of the chest, and inosculate with the aortic intercostals; to each space there are two arteries which either arise separately or by common trunks and run along the borders of the rib. Besides supplying the intercostal muscles, they send branches to the pectoral muscles and mammary gland.

The **perforating arteries** pass forward to the front of the chest through the first six intercostal spaces; they then turn outwards, and after giving some branches to the front of the sternum, are distributed to the pectoral muscles and mammary gland. Those intended for the mammary gland are of larger size than the rest.

The **musculo-phrenic artery**, proceeding from the internal mammary at the interspace between the sixth and seventh ribs, passes downwards and outwards over the cartilages of the false ribs to the last intercostal space. It pierces the diaphragm at the attachment of that muscle to the eighth rib, and sends branches to its muscular structure, and others to the intercostal spaces of the false ribs which

form the anterior intercostal arteries of those spaces, and are distributed in the same way as those above described.

The **superior epigastric artery** descends in the sheath of the rectus muscle, and gives off branches which are distributed to the muscles of the abdominal wall. It anastomoses with the deep epigastric, a branch of the external iliac.

The mammary arteries are remarkable for the number of their inosculations, and for the distant parts of the arterial system which they serve to connect. They anastomose with each other, and their inosculations, with the thoracic aorta, encircle the thorax. On the parietes of this cavity their branches connect the axillary and subclavian arteries: on the diaphragm they form a link in the chain of inosculations between the subclavian artery and abdominal aorta; and in the parietes of the abdomen they form an anastomosis most remarkable for the distance between those vessels which it serves to connect—namely, the arteries of the superior and inferior extremities.

The **THYROID AXIS** is a short trunk which arises from the front of the subclavian close to the inner border of the anterior scalenus, and divides almost immediately into three branches, inferior thyroid, supra-scapular, and transversalis colli.

The **INFERIOR THYROID ARTERY** ascends obliquely in a serpentine course behind the sheath of the carotid vessels, and in front of the longus colli, to the inferior and posterior part of the thyroid gland, to which it is distributed. It is in relation with the middle cervical ganglion of the sympathetic, which lies in front of it; and sends branches to the trachea, larynx, and œsophagus. Near its origin it gives off the following branch.

The **cervicalis ascendens,** a branch of the inferior thyroid, ascends upon the anterior tubercles of the transverse processes of the cervical vertebræ, lying in the groove between the scalenus anticus and rectus anticus major. It is distributed to the deep muscles and glands of the neck, and sends branches through the intervertebral foramina to supply the spinal cord and its membranes.

The **SUPRA-SCAPULAR** or **TRANSVERSALIS HUMERI ARTERY** passes obliquely outwards behind the clavicle, and over the ligament of the supra-scapular notch, to the supra-spinous fossa. It crosses in its course the scalenus anticus muscle, phrenic nerve, and subclavian artery; is distributed to the muscles of the dorsum of the scapula, and inosculates with the posterior scapular, and beneath the acromion process with the dorsal branch of the subscapular artery. At the supra-scapular notch it sends a large branch outwards, which pierces the trapezius muscle, and becomes cutaneous at the tip of the shoulder (*acromial*). The supra-scapular artery sometimes arises directly from the subclavian.

The **TRANSVERSALIS COLLI ARTERY** passes transversely across the subclavian triangle at the root of the neck, to the anterior border of the levator anguli scapulæ, where it divides into two terminal branches, the superficial cervical and posterior scapular. In

its course it lies above the suprascapular artery, and crosses the scaleni muscles and brachial plexus of nerves, often passing between the latter. At its bifurcation it is covered in by the edge of the trapezius.

The **superficial cervical artery**, its ascending branch, passes upwards under cover of the anterior border of the trapezius, and is distributed to the superficial muscles of the neck and deep cervical glands.

The **posterior scapular artery**, the proper continuation of the transversalis colli, passes backwards to the superior angle of the scapula, and then descends along the posterior border of that bone to its inferior angle, where it inosculates with the subscapular artery. In its course it lies under cover of the levator anguli scapulæ and rhomboidei muscles, distributes branches to them and neighbouring muscles, and inosculates with the arteries of the scapula and branches of the intercostal arteries.

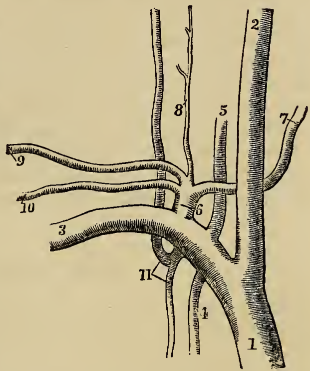


FIG. 238.—View of the branches of the right subclavian artery. 1. Innominate artery. 2. Common carotid. 3. Subclavian. 4. Internal mammary. 5. Vertebral. 6. Thyroid axis. 7. Inferior thyroid. 8. Ascending cervical. 9. Transversalis colli. 10. Supra-scapular. 11. Common trunk dividing into superior intercostal and profunda cervicis.

The superficial cervical and posterior scapular artery sometimes arise separately, the former from the thyroid axis, the latter from the third portion of the subclavian. By means of its numerous inosculations the transversalis colli artery maintains an important anastomotic communication between the branches of the external carotid, subclavian, and axillary arteries.

The **SUPERIOR INTERCOSTAL ARTERY** arises from the upper and back part of the subclavian artery behind the scalenus anticus, and, descending in front of the necks of the first two ribs, sends intercostal branches to the first two intercostal spaces, and *dorsal* branches to the muscles and integument of the back. The artery lies behind the pleura, to the outer side of the sympathetic nerve, and in the second intercostal space inosculates with the first aortic intercostal. It gives off the cervicalis profunda.

The **cervicalis profunda artery** (profunda cervicis) arises by a common trunk with the preceding, or more properly, is a branch of the superior intercostal, corresponding with the posterior branch of the other intercostal arteries. It passes backwards between the transverse processes of the seventh cervical and first dorsal vertebra, and ascends the back part of the neck, between the complexus and

semispinalis colli muscle. It inosculates with the princeps cervicis of the occipital artery, and with branches of the vertebral.

Varieties of the Subclavian Arteries.—Varieties in these arteries are rare; that which most frequently occurs is the origin of the right subclavian from the left extremity of the arch of the aorta, below the left subclavian artery. The vessel, in this case, curves behind the œsophagus and right carotid artery, and sometimes between the œsophagus and trachea, to the upper border of the first rib on the right side of the chest, where it assumes its ordinary course. Occasionally the left carotid and subclavian arise by a common trunk, as well as those on the right, so that there are two innominate arteries, and in rare cases the four branches all arise separately from the aorta, the right subclavian, however, retaining its normal position. Varieties in the branches of the subclavian are not unfrequent; the most interesting is the origin of the left vertebral from the arch of the aorta.

AXILLARY ARTERY.

The axillary artery passes outwards and downwards with a gentle curve through the axillary space from the lower border of the first rib to the lower border of the tendons of the latissimus dorsi and teres major, where it becomes the brachial. For convenience of description it is divided into three parts: the *first part* extends from the lower border of the first rib to the upper border of the pectoralis minor; the *second part* lies behind the pectoralis minor, and extends from the upper to the lower border of that muscle; the *third part* extends from the lower border of the pectoralis minor to the lower border of the tendons of the latissimus dorsi and teres major.

Relations.—In its *first part* the artery has *in front* the pectoralis major, costo-coracoid membrane, subclavius muscle, cephalic and acromial-thoracic veins; *behind* it has the first intercostal space, first serration of the serratus magnus, and the posterior thoracic nerve; to the *outer side* the brachial plexus; and to the *inner side* the axillary vein.

In the *second part* it has *in front* the pectoralis major and minor; *behind*, the subscapularis muscle and posterior cord of the brachial plexus; to the *outer side* the outer cord of the plexus; and to the *inner side* the inner cord of the plexus, and the axillary vein, the nerve being situated between the vein and artery.

In the *third part* it has *in front* the pectoralis major; *behind*, the subscapularis muscle, circumflex and musculo-spiral nerves, and the tendons of the teres major and latissimus dorsi; on the *outer side*, the outer head of the median and external cutaneous nerves, and coraco-brachialis muscle; and on the *inner side* the inner head of the median, internal cutaneous, lesser internal cutaneous and ulnar nerves, and the axillary vein.

Plan of the **Relations** of the *First Part* of the Axillary Artery.

In Front.
Pectoralis major,
Costo-coracoid membrane,
Acromial thoracic and cephalic veins,
Subclavius muscle.

Outer Side.		*Inner Side.*
Brachial plexus.	**Axillary Artery.** *First Part.*	Axillary vein.

Behind.
First intercostal space,
Serratus magnus,
Posterior thoracic nerve.

Plan of the **Relations** of the *Second Part* of the Axillary Artery.

In Front.
Pectoralis major,
Pectoralis minor.

Outer Side.		*Inner Side.*
Outer cord of plexus.	**Axillary Artery.** *Second Part.*	Inner cord of plexus, Axillary vein.

Behind.
Subscapularis,
Posterior cord of plexus.

Plan of the **Relations** of the *Third Part* of the Axillary Artery.

In Front.
Pectoralis major.

Outer Side.		*Inner Side.*
Outer head of median, External cutaneous, Coraco-brachialis.	**Axillary Artery.** *Third Part.*	Inner head of median, Internal cutaneous, Lesser internal cutaneous, Ulnar, Axillary vein.

Behind.
Subscapularis,
Musculo-spiral nerve,
Circumflex nerve,
Tendons of latissimus and teres major.

Branches.—The branches of the axillary artery are seven in number:—

Superior thoracic,
Acromial thoracic,
Inferior or long thoracic,
Alar thoracic,
Subscapular,
Anterior circumflex,
Posterior circumflex.

The superior thoracic and acromial thoracic are found in the triangular space above the pectoralis minor; the inferior thoracic and alar thoracic below the pectoralis minor; and the three remaining branches below the lower border of the subscapularis.

The **superior thoracic** (short thoracic), the highest of the branches of the axillary, and sometimes derived from the next, passes inwards to the chest in front of the pectoralis minor muscle, and is distributed to the pectoral muscles and walls of the chest. It anastomoses with the intercostal and mammary arteries.

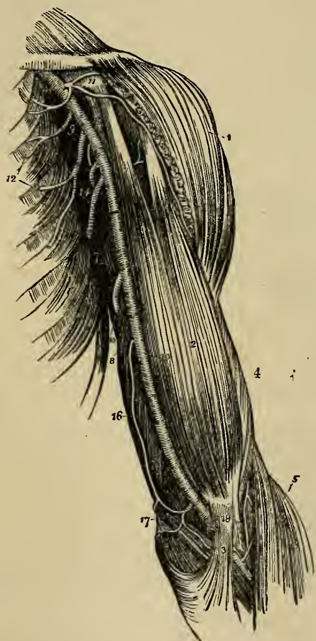


Fig. 239.—Axillary and brachial artery, with their branches. 1. Deltoid. 2. Biceps. 3. Tendinous process given off from the tendon of the biceps to the deep fascia of the forearm; this process separates the median basilic vein from the brachial artery. 4. Outer border of the brachialis anticus. 5. Supinator longus. 6. Coraco-brachialis. 7. Middle portion of the triceps. 8. Its inner head. 9. Axillary artery. 10. Brachial artery;—a dark bar marks the limit between these two vessels. 11. Acromial thoracic artery dividing into its three branches; the figure rests on the coracoid process. 12. The superior and long thoracic arteries. 13. Serratus magnus muscle. 14. Subscapular artery. The posterior circumflex and alar thoracic branches are seen in the figure between the inferior thoracic and subscapular. The anterior circumflex is observed between the two heads of the biceps, crossing the neck of the humerus. 15. Superior profunda. 16. Inferior profunda. 17. Anastomotica magna inosculating inferiorly with the anterior ulnar recurrent. 18. Termination of the superior profunda, inosculating with the radial recurrent in the interspace between the brachialis anticus and supinator longus.

The **acromial thoracic** (thoracic axis) is a short trunk which proceeds from the axillary in the space above the pectoralis minor muscle, and divides into four sets of branches: *pectoral*, which are distributed to the pectoral muscles, serratus magnus, and mammary gland; *acromial*, which pass outwards to the acromion, and inosculate with branches of the supra-scapular artery; *descending* (thoracica humeraria), a single branch, which follows the interspace between the deltoid and pectoralis major muscle, and is in relation with the cephalic vein; and one or more *clavicular* branches which pass to the subclavius muscle and supply it.

The **inferior** or **long thoracic** (external mammary) descends along the lower border of the pectoralis minor to the side of the chest. It is distributed to the pectoralis major and minor, serratus magnus, and mammary gland; inosculating with the superior thoracic, intercostal, and mammary arteries.

The **alar thoracic** is a small branch distributed to the plexus of nerves and glands in the axilla. It is frequently wanting, its place being supplied by a branch derived from one of the other thoracic branches.

The **subscapular artery**, the largest of the branches of the axillary, runs along the lower border of the subscapular muscle, to the inferior angle of the scapula, where it inosculates with the posterior scapular, a branch from the subclavian. It supplies the muscles of the under surface and inferior border of the scapula, and the side of the chest. At about an inch and a half from the axillary, it gives off a large branch, the **dorsalis scapulæ**, which passes backwards through the triangular space bounded by the teres minor, teres major, and scapular head of the triceps, and beneath the infra-spinatus muscle to the dorsum of the scapula, where it is distributed, inosculating with the supra-scapular and posterior scapular arteries.

The **circumflex arteries** wind around the neck of the humerus. The **anterior**, very small, passes beneath the coraco-brachialis and short head of the biceps, and sends a branch upwards along the bicipital groove to supply the shoulder-joint; it then passes beneath the deltoid, and distributes branches to that muscle, which anastomose with the posterior circumflex and acromial thoracic arteries.

The **posterior circumflex**, of larger size, passes backwards through the quadrangular space bounded by the teres minor and major, the scapular head of the triceps, and humerus, and is distributed to the deltoid muscle and shoulder-joint; it anastomoses with the anterior circumflex, subscapular, acromial thoracic, and superior profunda arteries. Sometimes this artery is a branch of the superior profunda of the brachial; it then ascends behind the tendon of the teres major, and is distributed to the deltoid without passing through the quadrangular space.

Varieties of the Axillary Artery.—The most frequent peculiarity of this kind is the division of the vessel into two trunks of equal size: a muscular trunk, which gives off some of the ordinary axillary branches and supplies the upper arm, and a continued trunk, which represents the brachial artery. The next most frequent variety is the high division of the radial which passes down the arm by the side of the brachial artery, and at the elbow takes its usual position, and is continued to its ordinary distribution in the hand. Sometimes there is a high division of the ulnar, that artery being given off in the axilla; at the elbow it passes superficially to the muscles attached to the internal condyle, and may in life be seen and felt pulsating immediately beneath the deep fascia.

BRACHIAL ARTERY.

The **brachial artery** passes down the inner side of the arm, from the lower border of the tendons of the latissimus dorsi and teres major, to a little below the bend of the elbow, where it divides into the radial and ulnar artery.

Relations.—In its course downwards, it rests on the triceps, musculo-spiral nerve, superior profunda artery, coraco-brachialis, and brachialis anticus. To its inner side is the internal cutaneous and ulnar nerve; to the outer side, the coraco-brachialis and biceps; in front it has the median basilic vein, from which it is separated by the bicipital fascia. The median nerve lies first to its outer side, then crosses in front of the artery, and at the bend of the elbow lies to its inner side. Its relations, within its sheath, are the venæ comites.

Plan of the **Relations** of the Brachial Artery.

	In Front.	
	Median nerve, Median-basilic vein, Bicipital fascia.	
Inner Side.		*Outer Side.*
Internal cutaneous nerve, Ulnar nerve, Median nerve.	**Brachial Artery.**	Median nerve, Coraco-brachialis, Biceps.
	Behind.	
	Triceps, Musculo-spiral nerve, Superior profunda artery, Coraco-brachialis, Brachialis anticus.	

The **branches** of the brachial artery are the—

Superior profunda,
Inferior profunda,
Anastomotica magna,
Muscular and nutrient.

The **superior profunda** arises opposite the lower border of the tendon of the latissimus dorsi, and winds around the humerus in the musculo-spiral groove, between the triceps and the bone, to the space between the brachialis anticus and supinator longus, where it inosculates with the radial recurrent artery. It accompanies the musculo-spiral nerve. In its course it gives off the *posterior articular* artery, which descends to the elbow-joint, and a more *superficial branch*, which descends by the side of the external intermuscular septum and inosculates with the posterior interosseous recurrent artery. The inferior muscular branches of the superior profunda inosculate with the inferior profunda, anastomotica magna, and ulnar recurrent. This artery supplies the coraco-brachialis, deltoid, triceps, brachialis anticus, and the muscles attached to the external condyle and condylar ridge.

The **inferior profunda** arises from about the middle of the

brachial artery, and descends with the ulnar nerve to the space between the inner condyle and olecranon, where it inosculates with the posterior ulnar recurrent. It also gives a branch to the front of the internal condyle, which anastomoses with the anterior ulnar recurrent and anastomotica magna. In its course it pierces the internal intermuscular septum from before backwards.

The **anastomotica magna** is given off nearly at right angles from the brachial, at about two inches above the joint. It passes directly inwards upon the brachialis anticus muscle, pierces the internal intermuscular septum, and winds around the humerus to inosculate with the superior profunda. On the brachialis anticus it divides into two branches, which inosculate with the anterior and posterior ulnar recurrent arteries, and with the inferior profunda.

The **muscular branches** are distributed to the muscles in the course of the artery, namely, coraco-brachialis, biceps, deltoid, brachialis anticus, and triceps.

The **nutrient branch** is given off at about the middle of the arm, and passes into the medullary foramen near the insertion of the coraco-brachialis muscle.

Varieties of the Brachial Artery.—The most frequent peculiarity in the distribution of branches from this artery is the high division of the radial, which arises generally from about the upper third of the brachial artery, and descends to its normal position at the bend of the elbow. The ulnar artery sometimes arises from the brachial at about two inches above the elbow, and pursues either a superficial or deep course to the wrist; and in some instances the interosseous artery arises from the brachial a little above the bend of the elbow. The two profunda arteries occasionally arise by a common trunk, or there may be two superior profundæ.

BEND OF THE ELBOW.

At the bend of the elbow the brachial artery terminates by dividing into radial and ulnar; it here lies deeply in a triangular space which is sometimes called the *antecubital fossa.* This space is bounded *above* by an imaginary line drawn across the arm about two inches above the condyles, on the *inner side* by the pronator radii teres, and on the *outer side* by the supinator longus; its *apex* is situated below, at the point where the pronator teres and supinator longus come in contact. The *floor* is formed by the lower part of the brachialis anticus, and the oblique fibres of the supinator brevis. The contents of the space, enumerated from within outwards, are the median nerve, brachial artery, and the tendon of the biceps. By displacing the supinator longus a little to the outer side, the musculo-spiral nerve and superior profunda artery can be brought into view; the former here divides into radial and posterior interosseous nerves, and the latter anastomoses with the radial recurrent artery, but neither the nerve nor the artery are strictly speaking contents of the triangle.

RADIAL ARTERY.

The radial artery, one of the divisions of the brachial, appears, from its direction, to be the continuation of that trunk. It runs along the radial side of the forearm, from the bend of the elbow to the wrist; it then turns backwards around the base of the thumb, beneath its extensor tendons, and passes between the two heads of the first dorsal interosseous muscle, into the palm of the hand. It next crosses the metacarpal bones to the ulnar side of the hand, forming the *deep palmar arch*, and terminates by inosculating with the superficial palmar arch.

Relations.—In the upper half of its course, the radial artery is situated between the supinator longus muscle, by which it is slightly overlapped, and the pronator radii teres; in the lower half between the tendons of the supinator longus and flexor carpi radialis. It rests in succession on the tendon of the biceps, supinator brevis, pronator radii teres, radial origin of the flexor sublimis, flexor longus pollicis, pronator quadratus, and radius; and is covered in by the integument and fasciæ. At the wrist it lies against the external lateral ligament and beneath the extensor tendons of the thumb; and, in the palm of the hand, beneath the flexor tendons. It is accompanied by venæ comites, and is in relation with the radial nerve, which lies to the outer side of its middle third.

Plan of the **Relations** of the Radial Artery in the Forearm.

In Front.

Deep fascia,
Supinator longus.

Inner Side.		*Outer Side.*
Pronator radii teres, Flexor carpi radialis.	**Radial Artery.**	Supinator longus, Radial nerve (middle third).

Behind.

Tendon of biceps,
Supinator brevis,
Pronator radii teres,
Flexor sublimis digitorum,
Flexor longus pollicis,
Pronator quadratus,
Radius.

The **branches** of the radial artery may be arranged into three groups, corresponding with the three regions—forearm, wrist, and hand; they are—

Forearm.

Recurrent radial,	Muscular.

Wrist.

Superficialis volæ,	Metacarpal,
Anterior carpal,	Dorsales pollicis,
Posterior carpal,	Dorsalis indicis.

Hand.

Princeps pollicis,	Interosseous,
Radialis indicis,	Perforating,
Recurrent.	

The **radial recurrent branch** is given off immediately below the elbow; it ascends in the space between the supinator longus and brachialis anticus, sends branches to the muscles arising from the external condyle, and inosculates with the terminal branches of the superior profunda.

The **muscular branches** are distributed to the muscles of the radial border of the forearm.

The **superficialis volæ** is given off by the radial artery while at the wrist. It passes between the fibres of the abductor pollicis muscle, and inosculates with the termination of the ulnar artery, completing the superficial palmar arch. This artery is variable in size, being sometimes as large as the continuation of the radial, at other times a mere muscular twig, or entirely wanting; when of large size it supplies the palmar side of the thumb and radial side of the index finger.

The **anterior carpal** passes inwards along the lower border of the pronator quadratus, and forms an arch by inosculating with the anterior carpal branch of the ulnar artery. From this arch twigs are given off to supply the wrist-joint.

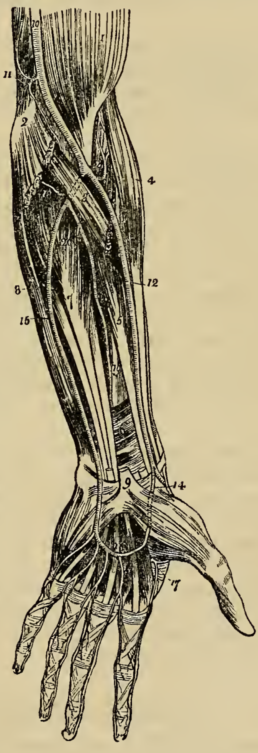


FIG. 240.—Arteries of the forearm. 1. Biceps. 2. Inner condyle of humerus with the humeral origin of the pronator radii teres and flexor carpi radialis divided across. 3. Deep portion of pronator radii teres. 4. Supinator longus. 5. Flexor longus pollicis. 6. Pronator quadratus. 7. Flexor profundus digitorum. 8. Flexor carpi ulnaris. 9. Annular ligament with the tendons passing beneath it into the palm of the hand; the figure is placed on the tendon of the palmaris longus, divided close to its insertion. 10. Brachial artery. 11. Anastomotica magna. 12. Radial artery. 13. Radial recurrent. 14. Superficialis volæ. 15. Ulnar artery. 16. Superficial palmar arch. 17. Princeps pollicis and radialis indicis. 18. Posterior ulnar recurrent. 19. Anterior interosseous. 20. Posterior interosseous, passing through the interosseous membrane.

The **posterior carpal** crosses the carpus transversely, and inosculates with the posterior carpal branch of the ulnar artery. Superiorly it inosculates with the termination of the anterior interosseous artery; inferiorly it gives off *dorsal interosseous branches*, which anastomose

with the perforating branches of the deep palmar arch, and run forward upon the dorsal interosseous muscles of the third and fourth metacarpal spaces.

The **metacarpal** or **first dorsal interosseous branch** often arises in common with the posterior carpal; it runs forward to the metacarpal space between the index and middle finger. At the cleft of the fingers it inosculates with the palmar digital artery, and gives off dorsal collateral branches. It is joined opposite the heads of the interosseous muscle by the perforating branch from the deep palmar arch.

The **dorsales pollicis** are two small branches which run along the sides of the dorsal aspect of the thumb.

The **dorsalis indicis** is a very small branch which runs along the radial border of the metacarpal bone and phalanges of the index finger.

The **princeps pollicis** (arteria magna pollicis), the great artery of the thumb, passes along the metacarpal bone of the thumb, between the first dorsal interosseous (abductor indicis) and flexor brevis pollicis to the base of the first phalanx; and, between the two heads of the latter muscle, in the groove of the tendon of the flexor longus, it divides into two collateral branches for the palmar borders of the thumb.

The **radialis indicis**, the digital branch of the radial side of the index finger, is directed inwards, between the first dorsal interosseous muscle and flexor brevis and adductor pollicis, to the side of the finger, along which it runs, forming its radial collateral artery. Near its origin it gives off a small branch (more frequently a direct branch of the radial), which inosculates with the superficial palmar arch.

The **palmar interosseous**, three or four in number, are branches of the deep palmar arch; they pass forward upon the interosseous muscles, and inosculate with the digital branches of the superficial arch, opposite the heads of the metacarpal bones.

The **perforating** branches, three in number, pass directly backwards between the heads of the dorsal interosseous muscles, and inosculate with the dorsal interosseous arteries.

The **recurrent** branches of the deep palmar arch pass upwards in front of the wrist-joint, and inosculate with the arterial arch formed by the anterior carpal arteries.

ULNAR ARTERY.

The ulnar artery, the other and larger division of the brachial, crosses the forearm obliquely to the commencement of its middle third; it then runs down the ulnar side of the forearm to the wrist, crosses the annular ligament into the hand, and forms the superficial palmar arch which terminates by inosculating with the superficialis volæ.

Relations.—In the upper or oblique portion of its course it lies upon the brachialis anticus and flexor profundus digitorum, and is

PLATE 23.

PALM AND BACK OF THE HAND.

FIGS. 1 AND 2.

A. Radial artery.
B. Median nerve.
C. Ulnar artery.
D. Annular ligament.
E. Ulnar nerve.
F. Insertion of flexor carpi ulnaris.
G. Pisiform bone.
H. Abductor minimi digiti.
I. Tendon of flexor carpi radialis.
K. Abductor pollicis.
L. Flexor brevis minimi digiti.
M. Flexor brevis pollicis.
O. Lumbricales.
P. Flexor tendons.
Q. Tendon of flexor longus pollicis.
R. Supinator longus.
S. Flexor sublimis digitorum.
T. Flexor carpi ulnaris.

FIG. 3.

A. Extensor communis digitorum.
B. Posterior annular ligament.
C. Radial nerve.
D. Ulnar nerve.
E. Radial artery.
F. Extensor carpi radialis brevior.
G. Extensor carpi radialis longior.
H. Extensor secundi internodii pollicis.
I. Extensor primi internodii pollicis.
K. Extensor minimi digiti.

PLATE 23.

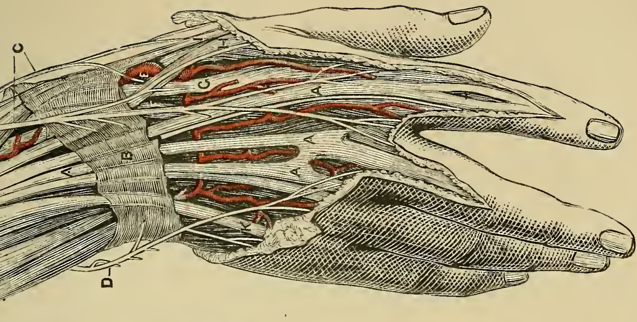


Fig. 3

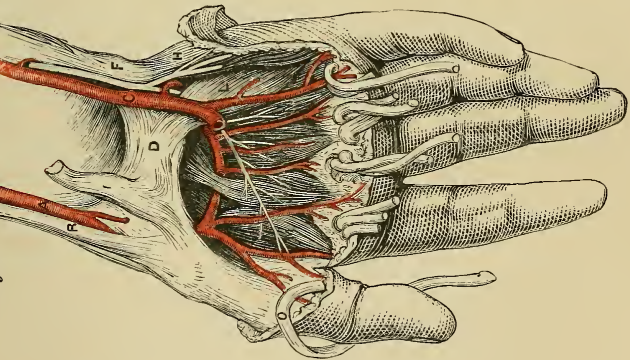


Fig. 2

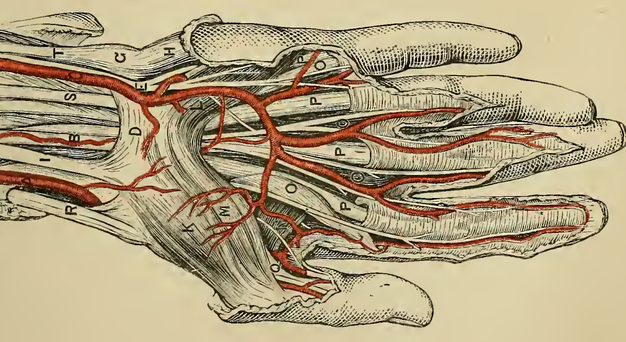


Fig. 1

covered in by the superficial layer of muscles of the forearm and median nerve. In the second part of its course, it is placed upon the flexor profundus and pronator quadratus, lying between the flexor carpi ulnaris and flexor sublimis digitorum. While crossing the annular ligament it is protected from injury by a strong tendinous arch, thrown over it from the pisiform bone; and in the palm it rests on the origin of the muscles of the little finger, and the tendons of the flexor sublimis, being covered in by the palmaris brevis muscle and palmar fascia. It is accompanied in its course by the venæ comites, and is in relation with the ulnar nerve for the lower two-thirds of its extent, the nerve lying to its ulnar side.

Plan of the **Relations** of the Ulnar Artery.

In Front.

Deep fascia,
Superficial layer of muscles,
Median nerve.

In the Hand.

Tendinous arch from the pisiform bone,
Palmaris brevis muscle,
Palmar fascia.

Inner Side.		*Outer Side.*
Flexor carpi ulnaris, Ulnar nerve (lower two-thirds).	**Ulnar Artery.**	Flexor sublimis digitorum.

Behind.

Brachialis anticus,
Flexor profundus digitorum,
Pronator quadratus.

In the Hand.

Annular ligament,
Origin of muscles of little finger,
Tendons of the flexor sublimis digitorum,
Divisions of the median and ulnar nerves.

The **branches** of the *ulnar artery* may be arranged, like those of the radial, into three groups:—

Forearm,
- Anterior ulnar recurrent,
- Posterior ulnar recurrent,
- Interosseous,
  - Anterior interosseous,
  - Posterior interosseous,
- Muscular.

Wrist,
- Anterior carpal,
- Posterior carpal,
- Metacarpal.

Hand,
- Communicating,
- Digital.

The **anterior ulnar recurrent**, arising immediately below the elbow, ascends in front of the joint between the pronator radii teres and brachialis anticus; it distributes branches to the adjacent

muscles, and inosculates with the anastomotica magna and inferior profunda. The two recurrent arteries frequently arise by a common trunk.

The **posterior ulnar recurrent**, larger than the preceding, arises immediately below the elbow-joint, and passes backwards, beneath the origin of the superficial layer of muscles; it then ascends between the two heads of the flexor carpi ulnaris, lying beneath the ulna nerve, and inosculates with the inferior profunda, anastomotica magna, and interosseous recurrent.

The **INTEROSSEOUS ARTERY** is a short trunk which arises from the ulnar, opposite the bicipital tuberosity of the radius, and passes backwards to the interosseous membrane, where it divides into the anterior and posterior interosseous artery.

The **anterior interosseous** passes down the forearm upon the interosseous membrane, in company with the anterior interosseous nerve, between the flexor profundus digitorum and flexor longus pollicis, and behind the pronator quadratus; it then passes through an opening in the interosseous membrane to the back of the wrist, where it inosculates with the posterior carpal branches of the radial and ulnar. The anterior interosseous artery gives off several *muscular* branches; *nutrient* branches to the radius and ulna; a *companion branch* to the *median* nerve (arteria comes nervi mediani); and at the upper border of the pronator quadratus, a small branch, which descends behind that muscle to inosculate with the anterior carpal arteries. The *median* artery is sometimes of large size, and occasionally takes the place of the superficial palmar arch.

The **posterior interosseous artery** passes backwards through an opening between the upper part of the interosseous membrane and the oblique ligament, and descends between the superficial and deep layer of muscles of the forearm to the back of the wrist, where it inosculates with the anterior interosseous and posterior carpal branches of the radial and ulnar. At its upper part it gives off a recurrent branch, *posterior interosseous recurrent*, which returns upon the elbow between the anconeus, extensor carpi ulnaris, and supinator brevis, and anastomoses with the posterior terminal branches of the superior profunda.

The **muscular branches** of the ulnar artery are distributed to the muscles of the ulnar border of the forearm.

The **anterior carpal**, a branch of small size, passes outwards upon the front of the wrist-joint, and contributes to form the *anterior carpal arch* by inosculating with the anterior carpal branch of the radial artery.

The **posterior carpal**, larger than the preceding, passes beneath the tendon of the flexor carpi ulnaris muscle to the back of the wrist-joint, where it inosculates with the posterior carpal branch of the radial artery, and forms a *posterior carpal arch.*

The **metacarpal**, often a branch of the preceding, passes along the inner border of the metacarpal bone of the little finger, and forms the dorsal collateral branch of that finger.

The **communicating** or deep branch arises close to the annular ligament, and dips between the abductor minimi digiti and flexor brevis to inosculate with the termination of the deep palmar arch. It is accompanied by the deep palmar branch of the ulnar nerve.

The **digital branches,** four in number, are given off from the convexity of the superficial palmar arch. The first and smallest is distributed to the ulnar side of the little finger. The other three are short trunks, which divide between the heads of the metacarpal bones, and form the collateral branch of the radial side of the little finger, the collateral branches of the ring and middle finger, and the collateral branch of the ulnar side of the index finger. On the last phalanx, the collateral arteries communicate and form an arch, from which numerous branches are given off to the tip of the finger.

The arteries of the hand are subject to frequent variety of distribution.

THORACIC AORTA.

The thoracic aorta commences at the lower border and left side of the fifth dorsal vertebra, passes slightly to the right as it descends, and terminates in front of the last dorsal vertebra by passing through the aortic opening of the diaphragm.

Relations.—The artery is situated in the posterior mediastinum of the thorax, and has *behind* it the vertebral column and vena azygos minor; in *front* the left pulmonary artery, left bronchus, pericardium, and œsophagus; on the *right side* the thoracic duct, vena azygos major and œsophagus; and on the *left side*, the pleura and left lung, and the œsophagus. The œsophagus lies first to its right side, then in front, and at the upper surface of the diaphragm is placed to the left of the artery although still in front of it.

Plan of the **Relations** of the Thoracic Aorta.

In Front.
Left pulmonary artery,
Left bronchus,
Pericardium,
Œsophagus.

Right Side.		*Left Side.*
Œsophagus, Vena azygos major, Thoracic duct.	**Thoracic Aorta.**	Pleura, Left lung, Œsophagus.

Behind.
Vertebral column,
Vena azygos minor.

Branches.—The branches of the thoracic aorta are as follows:—

Pericardiac, Œsophageal,
Bronchial, Posterior mediastinal,
Intercostal.

The **pericardiac** arteries are a few small and irregular branches distributed to the pericardium.

The **BRONCHIAL ARTERIES**, generally three in number, one for the right lung, and two for the left, vary both in size and origin; the right often proceeding from a short trunk common to it and one of the left bronchial branches, or from the first aortic intercostal. They take their course to the back of the root of the lung, and accompany the ramifications of the bronchial tubes through its substance; giving twigs also to the bronchial glands, œsophagus, and pericardium.

The **ŒSOPHAGEAL ARTERIES**, five or six in number, arise from the anterior part of the aorta, and are distributed to the œsophagus, establishing a chain of anastomoses along that tube: the superior inosculate with the bronchial arteries, and with œsophageal branches of the inferior thyroid arteries; the inferior with similar branches of the phrenic and gastric arteries.

The **posterior mediastinal** arteries are small twigs distributed to the lymphatic glands and cellular tissue of the posterior mediastinum.

The **INTERCOSTAL** or posterior intercostal arteries arise from the posterior part of the aorta; they are ten in number at each side, the first intercostal space being supplied by the superior intercostal artery, a branch of the subclavian. The right intercostals are longer than the left, on account of the position of the aorta. They ascend somewhat obliquely from their origin, and cross the vertebral column behind the thoracic duct, vena azygos major, and sympathetic nerve, to the intercostal spaces; the left passing beneath the superior intercostal vein, vena azygos minor, and sympathetic. In the intercostal space, or rather on the external intercostal muscle, each artery gives off a *dorsal branch*, which passes back between the transverse processes of the vertebræ, lying internally to the middle costo-transverse ligament, and divides into a *spinal* branch, which supplies the spinal cord and vertebræ, and a *muscular* branch, distributed to the muscles and integument of the back. The intercostal artery then comes into relation with its vein and nerve, the former being above, the latter below, and ascends obliquely to the lower border of the rib, with which it comes into relation near the angle of the bone. It then runs along the lower border of the rib, lying between the two planes of intercostal muscles to the front of the chest, where it inosculates with the superior anterior intercostal branch of the internal mammary.

Besides the *dorsal branch* and several small muscular branches, the intercostal artery, at about the middle of its course, gives off a large *inferior branch*, which runs along the upper border of the rib below to the fore part of the chest, and inosculates with the inferior anterior intercostal branch of the internal mammary.

While between the two planes of intercostal muscles, the intercostal artery is protected from pressure by little tendinous arches thrown across it and attached by each extremity to the bone. The upper pair of intercostal arteries inosculate with the superior inter-

costals of the subclavian; the lower intercostals anastomose with the lumbar and epigastric arteries in the parietes of the abdomen.

ABDOMINAL AORTA.

The abdominal aorta enters the abdomen through the aortic opening of the diaphragm, and between the two pillars of that muscle. In its course downwards, it lies on the vertebral column to the left of the middle line, and terminates on the fourth lumbar vertebra, by dividing into the two common iliac arteries. Its point of bifurcation is situated a little below and to the left of the level of the umbilicus. It has lying in *front* of it the lesser omentum and stomach, branches of the solar plexus and cœliac axis, the splenic vein, the left renal vein, pancreas, transverse duodenum, mesentery, and aortic plexus, and is in relation *behind* with the thoracic duct, receptaculum chyli, left lumbar veins, and vertebral column. On its *left side* is situated the left semilunar ganglion, supra-renal capsule, and sympathetic nerve; on its *right* the right crus of the diaphragm, inferior vena cava, right semilunar ganglion, thoracic duct, and commencement of the vena azygos major.

Plan of the **Relations** of the Abdominal Aorta.

	In Front. Lesser omentum and stomach, Branches of cœliac axis and solar plexus, Splenic vein, Pancreas, Left renal vein, Transverse duodenum, Mesentery, Aortic plexus.	
Right Side. Right crus of diaphragm, Vena cava, Right semilunar ganglion, Thoracic duct, Vena azygos major.	**Abdominal Aorta.**	*Left Side.* Left semilunar ganglion, Left supra-renal capsule, Sympathetic nerve.
	Behind. Thoracic duct, Receptaculum chyli, Left lumbar veins, Vertebral column.	

Branches.—The branches of the abdominal aorta are the following:—

Phrenic,
Cœliac axis, { Gastric, Hepatic, Splenic,
Superior mesenteric,
Spermatic,
Inferior mesenteric,
Supra-renal,
Renal,
Lumbar,
Sacra media.

The **PHRENIC ARTERIES** are given off (frequently by a common trunk) from the anterior part of the aorta as soon as that vessel has emerged through the aortic opening. Passing obliquely outwards on the under surface of the diaphragm, each artery divides into two branches, an *internal branch*, which runs forwards and inosculates with its fellow of the opposite side in front of the œsophageal opening; and an *external branch*, which proceeds outwards towards the great circumference of the muscle, and sends branches to the supra-renal capsules. The phrenic arteries inosculate with branches of the internal mammary, intercostal, epigastric, œsophageal, gastric, hepatic, and supra-renal arteries. They are not unfrequently derived from the cœliac axis, or from one of its divisions, and sometimes they give origin to the supra-renal arteries.

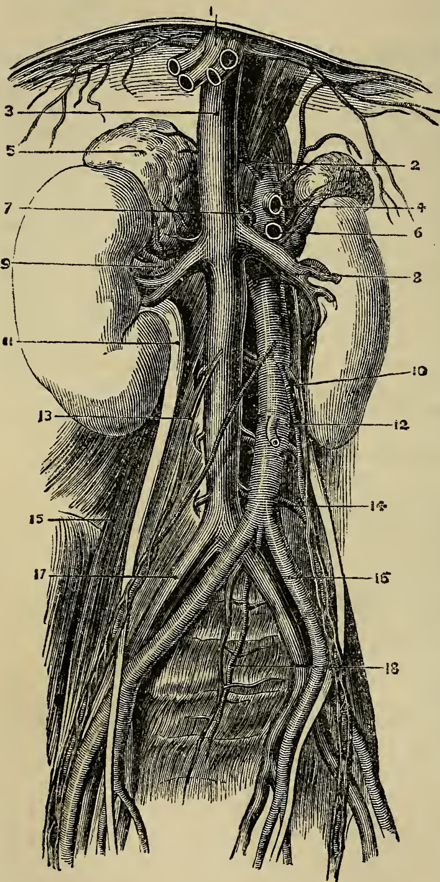


FIG. 241.—Abdominal aorta and inferior vena cava. 1. Hepatic veins (cut). 2. Phrenic arteries. 3. Vena cava. 4. Cœliac axis (cut). 5. Supra-renal capsule. 6. Superior mesenteric artery (cut). 7. Supra-renal artery. 8. Renal vein. 9. Renal artery. 10. Left spermatic vessels. 11. Right ureter. 12. Inferior mesenteric artery. 13. Right spermatic vein. 14. A lumbar artery. 15. Psoas magnus muscle. 16. Common iliac artery. 17. Common iliac vein. 18. Sacra media artery.

The **CŒLIAC AXIS** is the first single trunk given off by the abdominal aorta. It arises opposite the upper border of the first lumbar vertebra, is about half an inch in length, and divides into three large branches, gastric, hepatic, and splenic.

Relations.—The trunk of the cœliac axis has in relation with it, *in front*, the lesser omentum; on the *right side*, the right semilunar ganglion and lobus Spigelii of the liver; on the *left side*, the left semilunar ganglion and cardiac portion of the stomach; and *below*, the upper border of the pancreas and lesser curve of the stomach. It is completely surrounded by the solar plexus.

The **GASTRIC ARTERY** (coronaria ventriculi), the smallest of the three branches of the cœliac axis, ascends between the two

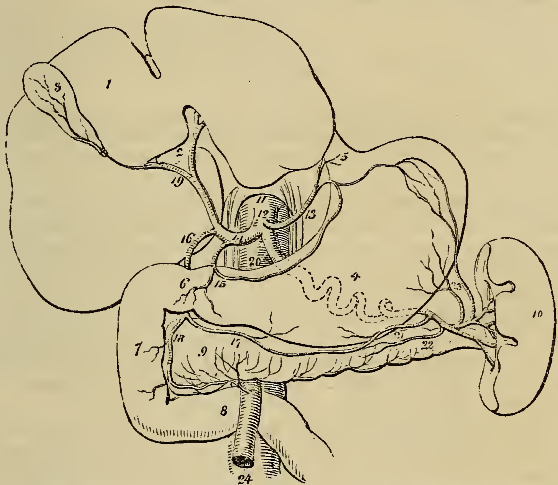


FIG. 242.—Branches of the cœliac axis. 1. Liver. 2. Its transverse fissure. 3. Gall-bladder. 4. Stomach. 5. Œsophagus. 6. Pylorus. 7. Duodenum, descending portion. 8. Transverse portion of the duodenum. 9. Pancreas. 10. Spleen. 11. Aorta. 12. Cœliac axis. 13. Gastric artery. 14. Hepatic artery. 15. Its pyloric branch. 16. Gastro-duodenal. 17. Gastro-epiploica dextra. 18. Superior pancreatico-duodenal, inosculating with the inferior pancreatico-duodenal. 19. Division of the hepatic artery into right and left branches; the right giving off the cystic branch. 20. Splenic artery, traced by dotted lines behind the stomach to the spleen; the figure rests on the aorta. 21. Gastro-epiploica sinistra, inosculating along the great curvature of the stomach with the gastro-epiploica dextra. 22. Pancreatica magna. 23. Vasa brevia to the great end of the stomach, inosculating with the gastric artery. 24. Superior mesenteric artery, emerging from between the pancreas and transverse portion of the duodenum.

layers of the lesser omentum to the cardiac orifice of the stomach, then runs along the lesser curvature to the pylorus, and inosculates with the pyloric branch of the hepatic. It is distributed to the lower extremity of the œsophagus and lesser curve of the stomach; and anastomoses with the œsophageal arteries, vasa brevia of the splenic artery, and pyloric branch of the hepatic artery.

The **HEPATIC ARTERY** curves forward, and ascends along the right border of the lesser omentum to the liver, where it divides

into two branches (right and left), which enter the transverse fissure, and are distributed along the portal canals to the right and left lobes.* It is in relation, in the right border of the lesser omentum, with the ductus communis choledochus and portal vein, lying to the left of the former structure and on a plane anterior to the latter; it is surrounded by the hepatic plexus of nerves, and numerous lymphatics. There are sometimes two hepatic arteries, in which case one is derived from the superior mesenteric.

The **branches** of the hepatic artery are the—

Pyloric,	Gastro-epiploica dextra,
Gastro-duodenal,	Pancreatico-duodenalis superior,
Cystic.	

The **pyloric branch**, given off from the hepatic near the pylorus, is distributed to the commencement of the duodenum and to the lesser curve of the stomach, where it inosculates with the gastric artery.

The **gastro-duodenal artery** is a short but large trunk, which descends behind the pylorus, and divides into two branches, the gastro-epiploica dextra, and pancreatico-duodenalis superior. Previously to its division it gives off some *inferior pyloric* branches to the small end of the stomach.

The **gastro-epiploica dextra** runs along the great curve of the stomach, lying between the two layers of the great omentum, and inosculates at about its middle with the gastro-epiploica sinistra, a branch of the splenic artery. It supplies the greater curve of the stomach and great omentum; hence its name.

The **pancreatico-duodenalis superior** curves along the fixed border of the duodenum, partly concealed by the attachment of the pancreas, and is distributed to the pancreas and duodenum. It inosculates inferiorly with the inferior pancreatico-duodenalis and pancreatic branches of the superior mesenteric artery.

The **cystic artery**, generally a branch of the right hepatic, is of small size, and ramifies between the coats of the gall-bladder, previously to its distribution to the mucous membrane.

The **SPLENIC ARTERY**, the largest of the three branches of the cœliac axis, passes horizontally to the left along the upper border of the pancreas, and divides into five or six large branches, which enter the hilum of the spleen, and are distributed to its structure. In its course the vessel is tortuous and serpentine, frequently making a complete turn upon itself. It lies in a narrow groove in the upper border of the pancreas, and is accompanied by the splenic vein which lies beneath it, and by the splenic plexus of nerves.

The **branches** of the splenic artery are the—

Pancreaticæ parvæ,	Vasa brevia,
Pancreatica magna,	Gastro-epiploica sinistra.

* For the mode of distribution of the hepatic artery within the liver, see the "Structural Anatomy" of that organ in the Part on Splanchnology.

The **pancreaticæ parvæ** are numerous small branches distributed to the pancreas, as the splenic artery runs along its upper border. One of these, larger than the rest, follows the course of the pancreatic duct, and is called *pancreatica magna.*

The **vasa brevia** are five or six branches of small size which pass from the extremity of the splenic artery and its terminal branches, between the layers of the gastro-splenic omentum, to the great end of the stomach, to which they are distributed, inosculating with branches of the gastric artery and gastro-epiploica sinistra.

The **gastro-epiploica sinistra** appears to be the continuation of the splenic artery; it passes forwards from left to right, along the great curve of the stomach, lying between the layers of the great omentum, and inosculates with the gastro-epiploica dextra. It is distributed to the greater curve of the stomach and great omentum.

The **SUPERIOR MESENTERIC ARTERY**, the second of the single trunks, and next in size to the cœliac axis, arises from the aorta immediately below that vessel, and behind the pancreas. It passes forwards between the pancreas and transverse duodenum, and descends within the layers of the mesentery, to the right iliac fossa, where it terminates, much reduced in size. In its course it forms a curve, the convexity being to the left, the concavity to the right; is in relation near its commencement with the portal vein, and is accompanied by two veins, and the superior mesenteric plexus of nerves.

The **branches** of the superior mesenteric artery are—

Pancreatico-duodenalis inferior,	Ileo-colica,
	Colica dextra,
Vasa intestini tenuis,	Colica media.

The **pancreatico-duodenalis inferior** is a small branch which arises from the superior mesenteric while behind the pancreas, and curves upwards along the line of junction of the pancreas, and duodenum. It supplies both those organs, and inosculates with the pancreatico-duodenal branch of the hepatic.

The **vasa intestini tenuis** arises from the convexity of the superior mesenteric artery. They vary from fifteen to twenty in number, and are distributed to the small intestine from the duodenum to the termination of the ileum. In their course between the layers of the mesentery, they form a series of arches by the inosculation of their larger branches; from these are developed secondary arches, and from the latter a third series of arches, from which the branches arise which are distributed to the coats of the intestine. From the middle branches a fourth and sometimes even a fifth series of arches is produced. By means of these arches a direct communication is established between all the branches given off from the convexity of the superior mesenteric artery; the upper branch inosculates with the inferior pancreatico-duodenal, the lower with the ileo-colic.

The **ileo-colic artery** is the last branch given off by the con-

cavity of the superior mesenteric. It descends to the right iliac fossa, and divides into branches which communicate and form arches, from which branches are distributed to the termination of the ileum, cæcum, and commencement of the colon. This artery inosculates on the one hand with the termination of the mesenteric trunk; on the other, with the colica dextra.

The **colica dextra** arises from about the middle of the concavity

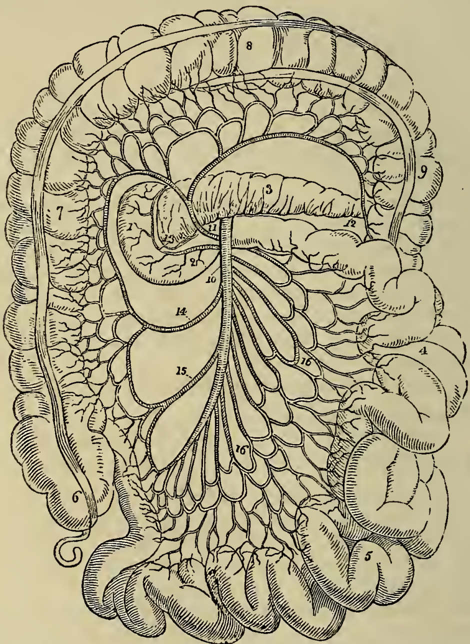


Fig. 243.—Course and distribution of the superior mesenteric artery. 1. Descending portion of the duodenum. 2. Transverse portion. 3. Pancreas. 4. Jejunum. 5. Ileum. 6. Cæcum and appendix vermiformis. 7. Ascending colon. 8. Transverse colon. 9. Descending colon. 10. Superior mesenteric artery. 11. Colica media. 12. The branch which inosculates with the colica sinistra. 13. Pancreatico-duodenalis inferior. 14. Colica dextra. 15. Ileo-colica. 16, 16. Vasa intestini tenuis.

of the superior mesenteric, and passing outwards behind the peritoneum, divides into branches which form arches, and are distributed to the ascending colon. Its descending branches inosculate with the ileo-colic, the ascending with the colica media.

The **colica media** arises from the upper part of the concavity of the superior mesenteric, and passes forward between the layers of the transverse mesocolon, where it forms arches, and is distributed to

the transverse colon. It inosculates on the right with the colica dextra; on the left, with the colica sinistra, a branch of the inferior mesenteric artery.

The **SPERMATIC ARTERIES** are two small vessels which arise from the front of the aorta below the superior mesenteric;

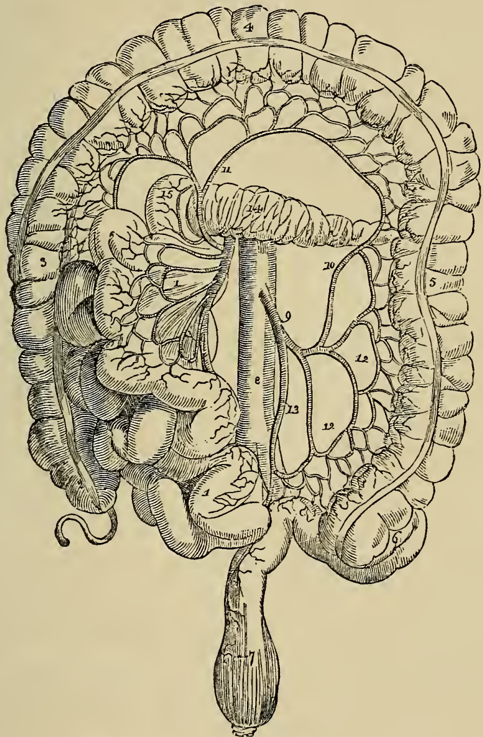


FIG. 244.—Branches of the inferior mesenteric artery. 1, 1. The superior mesenteric, and small intestines turned over to the right side. 2. Cæcum and appendix vermiformis. 3. Ascending colon. 4. Transverse colon drawn upwards. 5. Descending colon. 6. Sigmoid flexure. 7. Rectum. 8. Aorta. 9. Inferior mesenteric artery. 10. Colica sinistra, inosculating with (11) colica media. 12, 12. Sigmoid branches. 13. Superior hæmorrhoidal artery. 14. Pancreas. 15. Descending portion of the duodenum.

from their origin each artery passes obliquely outwards, and accompanies the corresponding ureter along the front of the psoas muscle, to the border of the pelvis, where it is in relation with the external iliac artery. It is then directed outwards to the internal abdominal ring, and follows the course of the spermatic cord, along the sper-

matic canal and through the scrotum to the testicle, to which it is distributed. The right spermatic artery lies in front of the vena cava, and both vessels are accompanied by veins and by the spermatic plexuses of nerves. They anastomose with the deferential arteries, branches of the superior vesical, and with the cremasteric arteries.

The spermatic arteries in the female (*ovarian*) descend into the pelvis and pass between the two layers of the broad ligaments of the uterus, to be distributed to the broad ligaments, ovaries, Fallopian tubes, and round ligaments; along the latter they are continued to the inguinal canal and labium at each side. They inosculate with the uterine arteries.

The **INFERIOR MESENTERIC ARTERY**, smaller than the superior, arises from the abdominal aorta, about two inches below the origin of the latter vessel, and descends between the layers of the left mesocolon, to the left iliac fossa, where it divides into three *branches:*

Colica sinistra, Sigmoid,
Superior hæmorrhoidal.

The **colica sinistra** is distributed to the descending colon; it passes upwards and outwards behind the peritoneum, and divides into two branches, one of which ascends to inosculate with the colica media, while the other descends to communicate with the sigmoid branch. The inosculation of the colica sinistra with the colica media is the largest arterial anastomosis in the body.

The **sigmoid artery** passes obliquely outwards behind the peritoneum and divides into branches which form arches, and are distributed to the sigmoid flexure of the colon. The superior branch inosculates with the colica sinistra, the inferior with the superior hæmorrhoidal artery.

The **superior hæmorrhoidal artery** is the continuation of the inferior mesenteric. It crosses the ureter and left common iliac artery, and descending between the two layers of the mesorectum, is distributed to the rectum as far as its middle, anastomosing with the middle and inferior hæmorrhoidal arteries.

The **SUPRA-RENAL** (capsular) are two small vessels which arise from the aorta immediately above the renal arteries, and are distributed to the supra-renal capsules. They are sometimes branches of the phrenic or of the renal arteries.

The **RENAL ARTERIES** (emulgent) are two large trunks given off from the sides of the aorta immediately below the superior mesenteric artery; the right is longer than the left, on account of the position of the aorta, and passes behind the vena cava to the kidney of that side. The left is somewhat higher than the right. They divide into several large branches previously to entering the kidney, and ramify very minutely in its vascular portion. The renal arteries supply several small branches to the supra-renal capsules, and one to the ureter.

The **LUMBAR ARTERIES** correspond with the intercostals in

the chest; they are four in number at each side, curve around the bodies of the lumbar vertebræ beneath the psoas muscles, and divide into two branches: one, *dorsal branch*, passes backwards between the transverse processes, and is distributed to the vertebræ and spinal cord and muscles of the back; the other, *parietal branch*, taking its course behind the quadratus lumborum, supplies the abdominal muscles, and inosculates with branches of the internal mammary and epigastric arteries in front, the terminal twigs of the intercostals above, and the ilio-lumbar and circumflex iliac below. The first lumbar artery runs along the lower border of the last rib; the last, along the crest of the ilium. In passing between the psoas muscle and the vertebræ, they are protected by a series of tendinous arches, which defend them and the communicating branches of the sympathetic nerve from pressure, during the action of the muscle.

The **SACRA MEDIA** arises from the posterior part of the aorta at its bifurcation, and descends along the middle of the anterior surface of the sacrum to the first piece of the coccyx, where it terminates by inosculating with the lateral sacral arteries. It distributes branches to the rectum and anterior sacral nerves, and inosculates at either side with the lateral sacral arteries.

Varieties in the Branches of the Abdominal Aorta.—The phrenic arteries are very rarely both derived from the aorta. One or both may be branches of the cœliac axis; one may proceed from the gastric artery, from the renal, or from the upper lumbar. There are occasionally three or more phrenic arteries. The cœliac axis is variable in length, and gives off its branches irregularly. There are sometimes two or even three hepatic arteries, one of which may be derived from the gastric or from the superior mesenteric. The colica media is sometimes derived from the hepatic artery. The spermatic arteries are variable both in origin and number. The right spermatic may be a branch of the renal; the left, of the inferior mesenteric. The supra-renal arteries may be derived from the phrenic or renal arteries. The renal arteries present several varieties in number; there may be three or even four on one side, and one only on the other. When there are several renal arteries on one side, one may arise from the common iliac artery, from the front of the aorta near its lower part, or from the internal iliac.

COMMON ILIAC ARTERIES.

The abdominal aorta divides opposite the fourth lumbar vertebra into the two common iliac arteries. Sometimes the bifurcation takes place as high as the third, and occasionally as low as the fifth. The common iliac arteries are about two inches in length; they diverge from the termination of the aorta, and pass downwards and outwards at each side to the margin of the pelvis, opposite the sacro-iliac symphysis, where they divide into the internal and external iliac. In old persons the common iliac arteries are more or less dilated and curved in their course. The *right artery* is somewhat

longer than the left, and forms a more obtuse angle with the termination of the aorta; the angle of bifurcation is greater in the female than in the male.

Relations.—The relations of the two arteries are different at the two sides of the body. The *right* common iliac is in relation in front with the peritoneum, and is crossed at its bifurcation by the ureter. It is in relation behind with the two common iliac veins, and externally with the psoas magnus, vena cava, and right common iliac vein. The *left* is in relation in front with the peritoneum, and is crossed by the rectum and superior hæmorrhoidal artery, and, at its bifurcation, by the ureter. It is in relation behind with the left common iliac vein, and externally with the psoas magnus.

The **INTERNAL ILIAC ARTERY** is a short trunk, varying

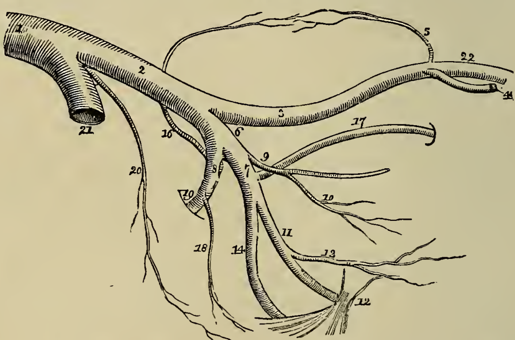


FIG. 245.—Iliac arteries. 1. Aorta. 2. Left common iliac artery. 3. External iliac. 4. Deep epigastric artery. 5. Deep circumflex iliac. 6. Internal iliac artery. 7. Its anterior trunk. 8. Its posterior trunk. 9. The pervious portion of the umbilical artery giving off (10) the superior vesical artery. 11. Internal pudic artery passing behind the spine of the ischium (12) and lesser sacro-ischiatic ligament. 13. Middle hæmorrhoidal artery. 14. Ischiatic artery, also passing behind the lesser sacro-ischiatic ligament to escape from the pelvis. 16. Ilio-lumbar ascending to inosculate with the circumflex iliac artery (5) and form an arch along the crest of the ilium. 17. Obturator artery. 18. Lateral sacral. 19. Gluteal artery passing through the upper part of the great sacro-ischiatic foramen. 20. Sacra media. 21. Right common iliac artery cut short. 22. Femoral artery.

in length from an inch to two inches. It descends obliquely forwards to a point opposite the upper margin of the great sacro-ischiatic foramen, where it divides into an anterior and a posterior trunk. In the fœtus, the internal iliac artery, under the name of *hypogastric* or *umbilical*, is continued onwards by the side of the upper part of the bladder to near its apex, whence it ascends by the side of the linea alba and urachus to the umbilicus, where it becomes the true umbilical artery. After birth, this artery ceases to be pervious beyond the side of the bladder, and the obliterated portion is converted into a fibrous cord. The projection of the two cords on the inner wall of the abdomen causes the depression at each side, which goes by the name of *peritoneal fossa.*

Relations.—This artery rests *posteriorly* on the lumbo-sacral cord, internal iliac vein, and origin of the pyriformis muscle; *externally* it is in relation with the psoas magnus muscle, and *anteriorly* with the peritoneum and ureter.

Plan of the **Relations** of the Internal Iliac Artery.

In Front.
Peritoneum,
Ureter.

Outer Side.
Psoas magnus.

Internal Iliac.

Behind.
Internal iliac vein,
Lumbo-sacral nerve,
Pyriformis muscle.

Branches.—The branches of the anterior trunk are the—

Superior vesical,	Vaginal,
Inferior vesical,	Obturator,
Middle hæmorrhoidal,	Ischiatic,
Uterine,	Internal pudic.

The branches of the posterior trunk are the—

Ilio-lumbar, Lateral sacral,
Gluteal.

Branches of the Anterior Trunk.

The **superior vesical** arteries are three or four small branches, which proceed from the pervious portion of the umbilical artery. They are distributed to the upper and middle part of the bladder. From one of these there passes off a small artery, the *deferential*, which accompanies the vas deferens to the spermatic cord.

The **inferior vesical**, somewhat larger than the preceding, passes down upon the side of the bladder to its base, and is distributed to that region, the vesiculæ seminales, and prostate gland.

The **middle hæmorrhoidal artery**, frequently a branch of the preceding, passes downwards to the rectum, to which it is distributed, inosculating with the superior and inferior hæmorrhoidal arteries. In the female it distributes branches to the vagina.

The **uterine artery** passes inwards between the layers of the broad ligament to the neck of the uterus, and ascends in a tortuous course along its lateral border. It gives branches to the vagina, lower part of the bladder, Fallopian tube (*tubaria*), ovary (*ovaria*), and round ligament, and inosculates with the spermatic or ovarian artery.

The **vaginal artery** corresponds in position with the inferior vesical in the male, and is distributed to the vagina and neighbouring parts of the bladder and rectum.

The **OBTURATOR ARTERY** (arising frequently from the posterior trunk of the internal iliac) passes forwards from the anterior trunk, a little below the brim of the pelvis, to the upper border of the obturator foramen. Escaping from the pelvis through a tendinous arch formed by the obturator membrane, it divides into two branches, internal and external.

Its *branches* within the pelvis are—an *iliac* branch, which supplies the bone of the iliac fossa, and inosculates with the ilio-lumbar artery; and a *pubic* branch which is given off close to the obturator foramen, and inosculates with its fellow of the opposite side, behind the pubes, and with the pubic branch of the deep epigastric artery.

The *internal* branch curves inwards around the bony margin of the obturator foramen, and distributes twigs to the obturator and adductor muscles, inosculating with the internal circumflex artery of the femoral.

FIG. 246.—Irregular origin of obturator artery from epigastric. Second variety internal to crural ring.

The *external* branch winds around the outer margin of the obturator foramen to the space between the gemellus inferior and quadratus femoris, where it inosculates with the ischiatic artery. In its course it inosculates also with the internal circumflex, and sends a small branch through the notch in the acetabulum to supply the ligamentum teres.

The obturator artery sometimes arises from the external iliac, but more frequently from the epigastric branch of that artery, in which case it runs down directly to the obturator foramen, either on the outer or inner side of the crural ring,—if to the inner side it is in contact with Gimbernat's ligament, and is in danger in the operation for female hernia; fortunately it is but rarely found in this dangerous position.

The **ISCHIATIC ARTERY** is the larger of the two terminal branches of the anterior division of the internal iliac. It passes downwards in front of the pyriformis and sacral plexus of nerves, lying internally to the pudic artery, to the lower part of the great ischiatic foramen, where it escapes from the pelvis between the inferior border of the pyriformis and coccygeus. It then descends in the space between the trochanter major and tuberosity of the ischium in company with the ischiatic nerves, and divides into several branches, the principal of which are—coccygeal, comes nervi ischiatici, and muscular.

The **coccygeal** branch pierces the great sacro-ischiatic ligament,

and is distributed to the coccygeus and levator ani, and to the integument around the anus and coccyx.

The **comes nervi ischiatici** is a slender branch, which accompanies the great ischiatic nerve, extending as far as the lower part of the thigh.

The **muscular** branches supply the muscles of the posterior part of the hip and thigh, and inosculate with the internal and external circumflex arteries, obturator, and superior perforating; some branches are also sent to the hip-joint.

The **INTERNAL PUDIC ARTERY**, the other terminal branch of the anterior trunk of the internal iliac, descends externally to

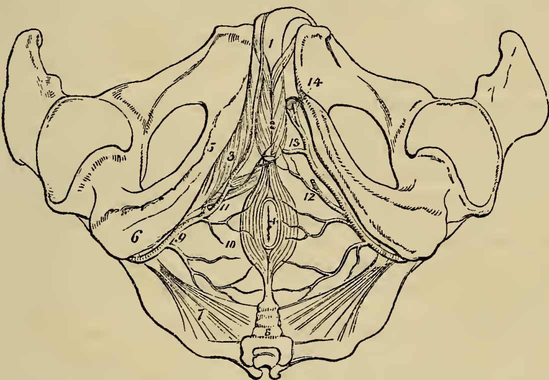


FIG. 247.—Arteries of the perineum; on the right side the superficial arteries are seen, on the left the deep. 1. The penis; the crus penis of the left side is cut through. 2. Acceleratores urinæ muscles, enclosing the bulbous portion of the corpus spongiosum. 3. Erector penis, spread out upon the crus penis of the right side. 4. Anus, surrounded by the sphincter ani. 5. Ramus of ischium and pubes. 6. Tuberosity of ischium. 7. Lesser sacro-ischiatic ligament. 8. Coccyx. 9. Internal pudic artery, crossing the spine of the ischium, and entering the perineum. 10. Inferior hæmorrhoidal branches. 11. Superficial perineal artery, giving off a small branch, transverse perineal, upon the transversus perinei muscle. 12. The same artery on the left side cut off. 13. Artery of the bulb. 14. The artery of the corpus cavernosum and artery of the dorsum of the penis.

the ischiatic artery to the lower part of the great ischiatic foramen. It emerges from the pelvis through the great sacro-ischiatic foramen between the lower border of the pyriformis and the coccygeus, crosses the spine of the ischium, and re-enters the pelvis through the lesser sacro-ischiatic foramen; in the next place it passes forward on the internal obturator muscle to the ramus of the ischium, being situated at about an inch from the margin of the tuberosity, and bound down by the obturator fascia; it then ascends by the side of the ramus of the ischium and pubes, and near the symphysis pubis pierces the triangular ligament of the perineum and divides into two terminal branches, the artery of the corpus cavernosum and the artery of the dorsum of the penis.

Branches.—The branches of the internal pudic artery within the pelvis are several small twigs to the levator ani and sacral nerves; and occasionally a branch which takes the place of the inferior vesical or middle hæmorrhoidal artery.

The *branches* given off externally to the pelvis are the—

Inferior hæmorrhoidal,	Artery of the bulb,
Superficial perineal,	Artery of the corpus cavernosum,
(Transverse perineal),	Artery of the dorsum of the penis.

The **inferior hæmorrhoidal arteries** are three or four small branches, given off by the internal pudic while behind the tuberosity of the ischium. They cross the ischio-rectal fossa, and are distributed to the anus and to the muscles and integument of the anal region of the perineum, anastomosing with the branches of the middle hæmorrhoidal.

The **superficial perineal artery** is given off near the attachment of the crus penis; it pierces the connecting layer of the perineal fascia and triangular ligament, and runs forward across the transversus perinei muscle, and along the groove between the accelerator urinæ and erector penis to the septum scroti, upon which it ramifies under the name of *arteria septi*. It distributes branches to the scrotum and perineum. One of the latter, larger than the rest, crosses the perineum, resting on the transversus perinei muscle, and is named the *transverse perineal*. There are often two superficial perineal arteries.

The **artery of the bulb** (bulbo-urethral) is given off from the pudic nearly opposite the opening for the transmission of the urethra; it passes almost transversely inwards behind the triangular ligament, and pierces that ligament to enter the corpus spongiosum at its bulbous extremity. It is distributed in the corpus spongiosum.

The **artery of the corpus cavernosum** pierces the crus penis, and runs forward in the interior of the corpus cavernosum, by the side of the septum pectiniforme. It ramifies in the parenchyma of the venous structure of the corpus cavernosum.

The **dorsal artery of the penis** (dorsalis penis) ascends between the two crura and symphysis pubis to the dorsum penis, and runs forward through the suspensory ligament, in the groove of the corpus cavernosum, to the glans, distributing branches in its course to the body of the organ and integument.

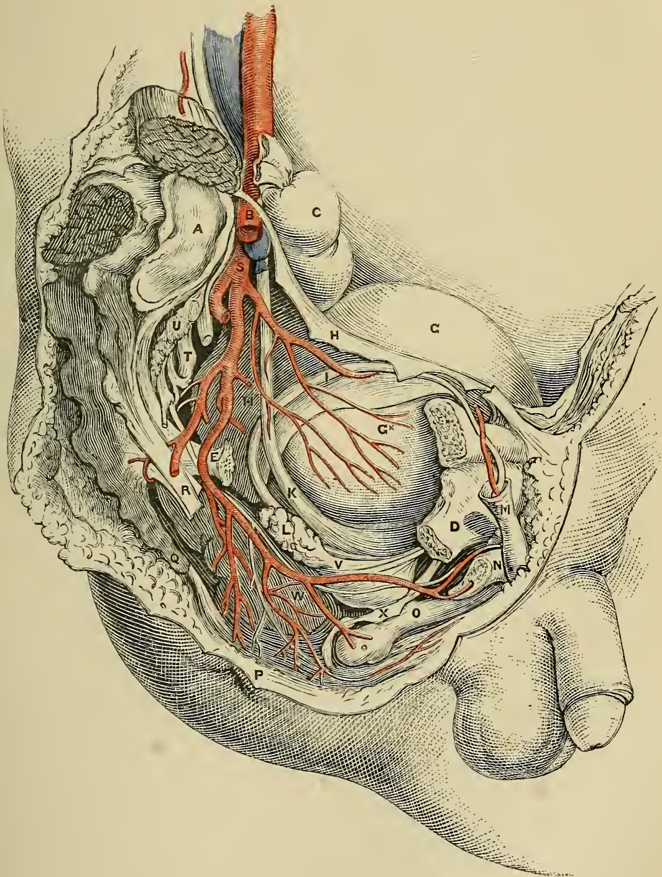
The **INTERNAL PUDIC ARTERY** in the female is smaller than in the male; its branches, with their distribution, are, in principle, the same. The superficial perineal artery supplies the homologue of the lateral half of the scrotum, namely, the greater labium. The artery of the bulb supplies the commencement of the vagina; the artery of the corpus cavernosum, the cavernous body of the clitoris; and the arteria dorsalis clitoridis, the dorsum of that organ.

PLATE 24.

SIDE VIEW OF MALE PELVIS.

A. Sacrum.
B. External iliac artery.
C. Upper end of rectum.
D. Ramus of pubes.
E. Spine of ischium (cut off).
G. Bladder covered by peritoneum.
G*. Bladder, uncovered by peritoneum.
H. Peritoneum reflected from side of bladder.
I. Vas deferens.
K. Ureter.
L. Vesicula seminales.
M. Spermatic cord.
N. Crus penis.
O. Urethra. **o.** Bulb.
P. Sphincter ani.
Q. Coccyx.
R. Sacro-sciatic ligament.
S. Internal iliac artery.
T. Sacral nerves.
U. Pyriformis muscle.
V. Internal pudic artery.
W. Levator ani muscle.
X. Triangular ligament (cut).

PLATE 24.



Branches of the Posterior Trunk.

The **ILIO-LUMBAR ARTERY** ascends beneath the external iliac vessels and psoas muscle, to the posterior part of the crest of the ilium, where it divides into two branches, a *lumbar branch* which supplies the psoas and quadratus lumborum, and sends a branch through the fifth intervertebral foramen to the spinal cord and its membranes; and an *iliac branch* which crosses the iliac fossa to the crest of the ilium, and inosculates with the lumbar arteries and deep circumflex iliac; in its course it distributes branches to the iliacus and abdominal muscles.

The **LATERAL SACRAL ARTERIES** are generally two in number on each side, superior and inferior. The *superior* passes inwards to the first sacral foramen, and is distributed to the contents of the spinal canal, from which it escapes by the posterior sacral foramen, and supplies the integument of the dorsum of the sacrum. The *inferior* passes down by the side of the anterior sacral foramina to the coccyx; it first pierces and then rests on the origin of the pyriformis, and sends twigs into the sacral canal to supply the sacral nerves. Both arteries inosculate with each other and with the sacra media.

The **GLUTEAL ARTERY** is the continuation of the posterior trunk of the internal iliac; it passes backwards between the lumbo-sacral and first sacral nerve through the upper part of the great sacro-ischiatic foramen and above the pyriformis muscle, and divides into three branches, superficial, deep superior, and deep inferior; while within the pelvis it gives off some muscular twigs to the iliacus and pyriformis, and at its escape from the pelvis, a *nutrient* artery to the ilium.

The **superficial branch** passes backwards between the gluteus maximus and medius, and is distributed to the gluteus maximus and to the integument of the gluteal and sacral region.

The **deep superior branch** passes forwards along the middle curved line of the ilium, between the gluteus medius and minimus to the anterior superior spinous process, where it inosculates with the superficial circumflex iliac and external circumflex of the femoral. There are frequently two arteries occupying the place of this branch.

The **deep inferior branches**, two or three in number, cross the gluteus minimus obliquely to the trochanter major, where they inosculate with branches of the external circumflex and ischiatic artery, and send branches through the gluteus minimus to supply the capsule of the hip-joint.

Varieties in the Branches of the Internal Iliac.—The most important of the varieties occurring among these branches is the origin of the dorsal artery of the penis from the internal iliac or ischiatic. The artery in this case passes forwards by the side of the prostate gland, and through the upper part of the triangular ligament of the urethra. It would be endangered in the operation of lithotomy. The dorsal artery of the penis is sometimes derived

from the obturator, and sometimes from one of the external pudic arteries. The artery of the bulb, in its normal course, passes almost transversely inwards to the corpus spongiosum. Occasionally, however, it is so oblique in direction as to render its division in lithotomy unavoidable.

The **EXTERNAL ILIAC ARTERY** of each side passes obliquely downwards along the inner border of the psoas muscle, from opposite the sacro-iliac symphysis to the femoral arch, where it becomes the femoral artery.

Relations.—It is in relation *in front* with the spermatic vessels, lymphatic vessels and glands, intestines, peritoneum, and a thin layer of fascia derived from the iliac fascia, which surrounds the artery and vein; near its termination it is crossed by the genital branch of the genito-crural nerve and the circumflex iliac vein. *Externally* it lies against the psoas muscle, from which it is separated by the iliac fascia; and *posteriorly* it is in relation with the external iliac vein, which, at the femoral arch, becomes placed to its inner side.

Plan of the **Relations** of the External Iliac Artery.

In Front.
Peritoneum, intestines, and iliac fascia,
Lymphatics,
Spermatic vessels,
Genito-crural nerve,
Circumflex iliac vein.

Inner Side.		*Outer Side.*
External iliac vein, Vas deferens.	**External Iliac.**	Psoas magnus, Iliac fascia.

Behind.
External iliac vein,
Psoas magnus.

Branches.—Besides several small twigs which supply the lymphatic glands and psoas muscle, the external iliac gives off two branches, the

Deep epigastric, Deep circumflex iliac.

The **DEEP EPIGASTRIC ARTERY** arises from the front of the external iliac near Poupart's ligament; and passing inwards between the peritoneum and transversalis fascia, ascends obliquely to the sheath of the rectus. It enters that sheath near its lower third, passes upwards behind the rectus muscle, to which it is distributed, and, in the substance of that muscle, inosculates, near the ensiform cartilage, with the termination (superior epigastric) of the internal mammary artery. It lies internally to the internal abdominal ring and immediately above the femoral ring, and is crossed near its origin by the vas deferens in the male, and the round ligament in the female.

The branches of the epigastric artery are—

A **cremasteric** branch which accompanies the spermatic cord, and after supplying the cremaster muscle inosculates with the spermatic artery.

A **pubic** branch which is distributed behind the pubes, and sends a small branch of communication downwards to the obturator artery.

Muscular branches which pass outwards between the abdominal muscles, and inosculate with the circumflex iliac, lumbar, and inferior intercostal arteries.

Superficial branches which pierce the rectus muscle, and are distributed to the integument of the abdomen.

The epigastric artery forms a prominence of the peritoneum, which divides the inguinal fossa into an internal and external portion ; it is from the former that direct inguinal hernia issues, and from the latter oblique inguinal hernia.

Triangle of Hesselbach.—This is a small triangular space, bounded externally by the deep epigastric artery, internally by the outer edge of the rectus abdominis, and below by Poupart's ligament and the crest of the pubes. In this space is situated the external abdominal ring, through which both direct and oblique inguinal hernia pass.

The **DEEP CIRCUMFLEX ILIAC** arises from the other side of the external iliac, a little below the epigastric artery. It ascends obliquely along Poupart's ligament, and curving around the crest of the ilium, inosculates with the ilio-lumbar and inferior lumbar artery. In its course the artery pierces the crural sheath and then lies between the transversalis muscle and fascia ; near its termination it pierces the transversalis muscle and becomes placed between it and the internal oblique. Opposite the anterior superior spinous process of the ilium, it gives off a large *ascending branch*, which passes upwards between the internal oblique and transversalis, and divides into numerous branches which supply the abdominal muscles, and inosculate with the inferior intercostal and the lumbar arteries.

FEMORAL ARTERY.

Emerging from beneath Poupart's ligament, the external iliac artery enters the thigh and becomes the femoral. The femoral artery passes down the inner side of the thigh, from Poupart's ligament, at a point midway between the anterior superior spinous process of the ilium and the symphysis pubis, to the opening in the adductor magnus, at the junction of the middle with the inferior third of the thigh, where it becomes the popliteal artery.

The femoral artery and vein are enclosed in a strong sheath, *femoral sheath*, which is formed for the greater part of its extent by fibrous and areolar tissue, and by a process of fascia sent inwards from the fascia lata. Near Poupart's ligament this sheath is much larger (infundibuliform) than the vessels it contains, and is continuous with the transversalis and iliac fascia. If the sheath be

opened at this point, the artery will be seen in contact with the outer wall of the sheath. The vein lies next the artery, being separated from it by a fibrous septum, and between the vein and the inner wall of the sheath, and divided from the vein by another thin fibrous septum, is a triangular interval (*femoral* or *crural canal*), into which the sac is protruded in femoral hernia. This space is occupied in the normal state of the parts by loose cellular tissue, and by lymphatic vessels which pierce the inner wall of the sheath to make their way to a gland, situated in the femoral or *crural* ring.

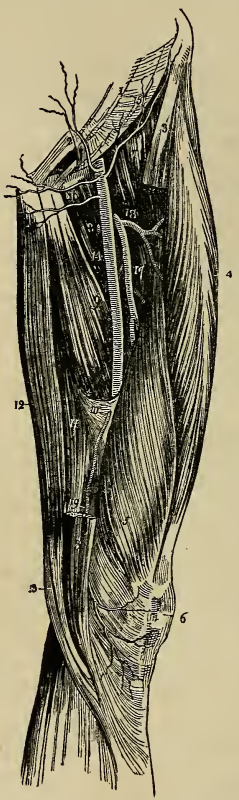


FIG. 248. — Anterior and inner aspect of the thigh, with the femoral artery. 1. Lower part of the tendon of the external oblique muscle. 2. External abdominal ring. 3, 3. Upper and lower part of the sartorius muscle; its middle portion being removed. 4. Rectus. 5. Vastus internus. 6. Patella. 7. Iliacus and psoas. 8. Pectineus. 9. Adductor longus. 10. Hunter's canal. 11. Adductor magnus. 12. Gracilis. 13. Tendon of the semi-tendinosus. 14. Femoral artery. 15. Superficial circumflex iliac artery. 2. Superficial epigastric artery. 16. The two external pudic arteries, superior and inferior. 17. Profunda artery, giving off (18) its external circumflex branch; and lower down the three perforating. A small bend of the internal circumflex artery (8) is seen behind the inner margin of the femoral, just below the inferior external pudic artery. 19. The anastomotica magna, descending to the knee, upon which it ramifies (6).

Relations. — The upper third of the femoral artery is superficial, being covered only by the integument, inguinal glands, and superficial and deep fascia. The lower two-thirds are covered by the sartorius muscle. To its *outer side* the artery is in relation with the psoas, and vastus internus muscles, and with the femoral vein at the upper part of the thigh. *Behind*, it rests on the inner border of the psoas; it is next separated from the pectineus by the femoral vein, profunda vein and artery, and then lies on the adductor longus to its termination; near the lower border of the adductor longus it is placed in an aponeurotic sheath or canal (called *Hunter's canal*), formed by an arch of tendinous fibres, thrown from the border of the adductor longus and the border of the opening in the adductor magnus, to the side of the vastus internus. To its *inner side* it is in relation at its upper part with the femoral vein, and lower down with the adductor longus and sartorius.

The immediate relations of the artery are the femoral vein, long saphenous nerve, and muscular nerve to the vastus internus. The vein at Poupart's ligament lies to the inner side of the artery; but lower down gets behind it, and inclines to its outer side. The muscular nerve lies to the outer side, and somewhat upon the sheath for the lower two-thirds of its extent; and the long saphenous nerve is situated within the sheath, and in front of the artery for the same extent.

Plan of the **Relations** of the Femoral Artery.

Front.
Fascia lata,
Long saphenous nerve,
Sartorius,
Aponeurotic canal.

Inner Side.		*Outer Side.*
Femoral vein, Adductor longus, Sartorius.	**Femoral Artery.**	Psoas, Vastus internus, Femoral vein.

Behind.
Psoas muscle,
Profunda vein,
Femoral vein,
Pectineus,
Adductor longus,
Adductor magnus.

Branches.—The branches of the femoral artery are the—

Superficial circumflex iliac,	Profunda, { External circumflex, Internal circumflex, Three perforating.
Superficial epigastric,	
Superior external pudic,	
Inferior external pudic,	Muscular,
	Anastomotica magna.

The **superficial circumflex iliac artery** arises from the femoral immediately below Poupart's ligament, and passes obliquely outwards towards the crest of the ilium, where it pierces the fascia lata. It supplies the integument of the groin, superficial fascia, and inguinal glands, and anastomoses with the deep circumflex iliac, gluteal and external circumflex arteries.

The **superficial epigastric** arises from the femoral immediately below Poupart's ligament, pierces the fascia lata, and ascends obliquely towards the umbilicus between the two layers of the superficial fascia. It distributes branches to the inguinal glands and integument, and inosculates with branches of the deep epigastric and internal mammary artery.

The **superior external pudic** arises near the superficial epigastric artery; it pierces the fascia lata at the saphenous opening, and passes transversely inwards, crossing the spermatic cord, to be distributed to the integument of the penis and scrotum in the male, and to the labia in the female.

The **inferior external pudic** arises from the femoral a little below, and sometimes in common with, the preceding; it crosses the femoral vein immediately below the termination of the internal saphena vein, and resting on the pectineus muscle reaches the inner border of the thigh, where it pierces the fascia lata, and is distributed to the integument of the external organs of generation and perineum. Both external pudics inosculate with the internal pudic artery.

The **PROFUNDA FEMORIS** arises from the outer and posterior side of the femoral artery about one inch and a half below Poupart's ligament ; it passes downwards and backwards and a little outwards, behind the adductor longus muscle, pierces the adductor magnus, and is distributed to the flexor muscles on the posterior part of the thigh. It is so large that it may be considered a *division* of the **common femoral,** in which case the continuation of the main trunk may be called **superficial.**

Relations.—In its course downwards it rests successively on the pectineus, iliacus, adductor brevis, and adductor magnus. To its *outer side* the tendinous insertion of the vastus internus muscle intervenes between it and the femur; on its *inner side* it is in relation with the pectineus, adductor brevis, and adductor magnus; and *in front* it is separated from the femoral artery, *above* by the profunda and femoral vein, and *below* by the adductor longus muscle.

Plan of the **Relations** of the Profunda Artery.

	In Front. Femoral vein, Profunda vein, Adductor longus.	
Inner Side. Pectineus, Adductor brevis, Adductor magnus.	**Profunda Artery.**	*Outer Side.* Vastus internus, Femur.
	Behind. Pectineus, Iliacus, Adductor brevis, Adductor magnus.	

Branches.—The branches of the profunda artery are the external circumflex, internal circumflex, and three perforating arteries.

The **external circumflex artery** passes outwards beneath the sartorius and rectus and in front of the crureus muscle, crossing between the divisions of the crural nerve, and divides into three sets of branches; *ascending*, which pass upwards beneath the sartorius, rectus, and tensor vaginæ femoris, and inosculate with the terminal branches of the gluteal artery; *descending*, which pass downwards beneath the rectus and along the margin of the vastus externus muscle to inosculate with the superior articular arteries of

the popliteal; and *middle*, which continue the original course of the artery around the thigh, pierce the vastus externus, and anastomose with branches of the ischiatic, internal circumflex, and superior perforating artery. It supplies the muscles of the anterior and outer side of the thigh.

The **internal circumflex artery** winds around the inner side of the neck of the femur, passing between the pectineus and psoas, and over the upper border of the adductor brevis to the tendon of the obturator externus, which it accompanies to the space between the quadratus femoris and upper border of the adductor magnus. While on the obturator externus it gives off a branch which is distributed to that muscle, the adductor brevis, and gracilis, and anastomoses with the obturator artery. It next gives off an *articular* branch, which enters the hip-joint through the notch in the acetabulum; and terminates in several branches which inosculate with the ischiatic, external circumflex, and superior perforating artery.

The **superior perforating artery** passes backwards near the lower border of the pectineus, pierces the adductor brevis and magnus near the femur, and is distributed to the posterior muscles of the thigh; inosculating with the circumflex, ischiatic, and middle perforating artery.

The **middle perforating artery** pierces the tendons of the adductor brevis and magnus, and is distributed like the superior; inosculating with the superior and inferior perforating. From this branch is given off the *nutrient* artery of the femur.

The **inferior perforating artery** is given off below the adductor brevis, and pierces the tendon of the adductor magnus, supplying it and the flexor muscles, and inosculating with the middle perforating artery above, and the articular branches of the popliteal below. It is through the medium of the branches of the profunda which inosculate above with branches of the internal iliac, and below with those of the popliteal artery, that the collateral circulation is maintained in the limb after ligature of the femoral artery.

The **muscular branches** are given off by the femoral artery throughout the whole of its course. They supply the muscles in immediate proximity with the artery, particularly those of the anterior aspect of the thigh. One of these branches, larger than the rest, arises from the femoral immediately below the origin of the profunda, and passing outwards between the sartorius and rectus, divides into branches, which are distributed to all the muscles of the anterior aspect of the thigh. This may be named the *superior muscular artery*.

The **anastomotica magna** arises from the femoral near its termination at the opening in the adductor magnus, and divides into a superficial and deep branch. The *superficial branch* accompanies the internal saphenous nerve to the knee, and piercing the fascia lata is distributed to the integument. The *deep branch* passes onwards through the substance of the vastus internus muscle, resting on the tendon of the adductor magnus to the knee, where it inoscu-

lates with the internal articular branches of the popliteal, and the recurrent of the anterior tibial. It also sends a branch through the vastus internus, which supplies the synovial membrane of the joint, and inosculates with the superior external articular artery and external circumflex.

POPLITEAL SPACE.

This is a space of a diamond shape, situated at the back of the knee-joint. It is bounded below by the outer and inner heads of the gastrocnemius, above by the outer and inner hamstrings, in front by the posterior ligament of the knee-joint, and is covered in behind by the fascia lata of the thigh. It contains the popliteal vessels and their branches, the divisions of the great sciatic nerve, termination of the external saphena vein, branches of the obturator and lesser sciatic nerves, lymphatic glands, and areolar tissue. The popliteal artery lies at the bottom of this space, immediately in contact with the ligamentum posticum Winslowii, the vein lying superficial to it, and the internal popliteal nerve superficial to both vein and artery; the external popliteal nerve (perineal) descends on the outer side of the space, in contact with the biceps tendon, and the lymphatic glands (four or five in number) surround the artery.

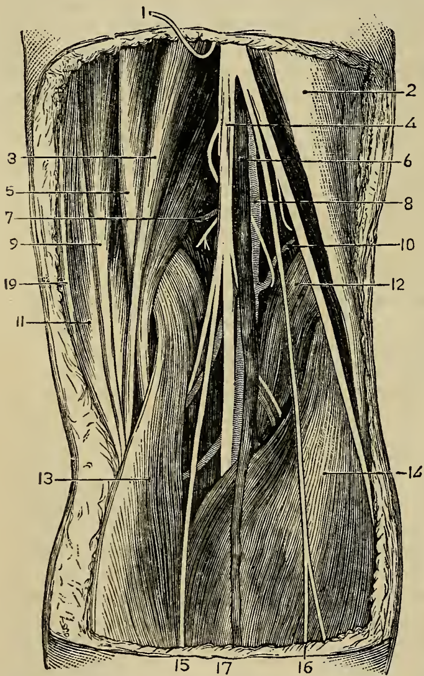


Fig. 249.—Popliteal space. 1. Branch of the small sciatic nerve (cut). 2. Biceps and external popliteal nerve. 3. Semi-tendinosus. 4. Internal popliteal nerve. 5. Semi-membranosus. 6. Popliteal vein. 7. Superior internal articular artery and nerve. 8. Popliteal artery. 9. Gracilis. 10. Superior external articular artery and nerve. 11. Sartorius. 12. Plantaris. 13. Gastrocnemius, inner head. 14. Gastrocnemius, outer head. 15. Communicans tibialis nerve. 16. Communicans peronei nerve. 17. External saphena vein. 19. Long saphenous nerve.

POPLITEAL ARTERY.

The popliteal artery (fig. 249) commences from the termination of the femoral at the opening in the adductor

magnus muscle, and passes obliquely outwards through the middle of the popliteal space to the lower border of the popliteus muscle, where it divides into the anterior and posterior tibial artery. In structure the popliteal artery is remarkable for the thickness of its walls.

Relations.—In its course downwards it rests on the femur, then on the posterior ligament of the knee-joint, then on the fascia covering the popliteus muscle. *Superficially* it is in relation with the semi-membranosus muscle, next with a quantity of fat which separates it from the deep fascia, and, near its termination, with the gastrocnemius, plantaris, and soleus; superficial and external to it is the popliteal vein, and still more superficial and external the internal popliteal nerve. By its *inner side* it is in relation with the semi-membranosus, internal condyle of the femur, and inner head of the gastrocnemius; and by its *outer side* with the biceps, external condyle of the femur, outer head of the gastrocnemius, plantaris, and soleus.

Plan of the **Relations** of the Popliteal Artery.

Superficially.
Semi-membranosus,
Popliteal nerve,
Popliteal vein,
Gastrocnemius,
Plantaris,
Soleus.

Inner Side.		*Outer Side.*
Semi-membranosus, Internal condyle, Gastrocnemius.	**Popliteal Artery.**	Biceps, External condyle, Gastrocnemius, Plantaris, Soleus.

Deeply.
Femur,
Ligamentum posticum Winslowii,
Popliteal fascia,
Popliteus.

Branches.—The branches of the popliteal artery are the—

Superior external articular,	Inferior external articular,
Superior internal articular,	Inferior internal articular,
Azygos articular,	Sural.

The **superior articular arteries**, *external* and *internal*, wind around the femur, immediately above the condyles, to the front of the knee-joint, anastomosing with each other, with the external circumflex, anastomotica magna, inferior articular, and recurrent of the anterior tibial. The external passes beneath the tendon of the biceps, and the internal through an arched opening beneath the tendon of the adductor magnus. They supply the knee-joint and lower part of the femur, and give branches to the vasti muscles.

The **azygos articular artery** pierces the posterior ligament of

the joint, the ligamentum posticum Winslowii, and supplies the crucial ligaments and synovial membrane. There are, frequently, several posterior articular arteries.

The **inferior articular arteries** wind around the head of the tibia immediately below the joint, and anastomose with each other, the superior articular arteries, and the recurrent of the anterior tibial. The external passes beneath the long external lateral ligament of the joint, the internal beneath the internal lateral ligament. They supply the knee-joint and the heads of the tibia and fibula.

The **sural arteries** (*sura*, the calf) are two muscular branches of large size, distributed to the two heads of the gastrocnemius muscle. Other *muscular* branches are given off from the upper part of the popliteal artery to supply the hamstring muscles.

ANTERIOR TIBIAL ARTERY.

The anterior tibial artery passes forwards between the two heads of the tibialis posticus muscle, and through the opening in the upper part of the interosseous membrane, to the anterior tibial region. It then runs down the anterior aspect of the leg to the ankle-joint, where it becomes the dorsalis pedis.

Relations.—In its course it rests on the interosseous membrane (to which it is connected by a little tendinous arch which is thrown across it), the lower part of the tibia, and the anterior ligament of the joint. In its upper third it is situated between the tibialis anticus and extensor longus digitorum, lower down between the tibialis anticus and extensor proprius pollicis; and just before it reaches the ankle it is crossed by the tendon of the extensor proprius pollicis, and becomes placed between that tendon and the tendons of the extensor longus digitorum. Its immediate relations are the venæ comites and anterior tibial nerve; the latter lies at first to its outer side, at about the middle of the leg it is placed superficially to the artery, and at the ankle is again at its outer side.

Plan of the **Relations** of the Anterior Tibial Artery.

Front.

Deep fascia,
Tibialis anticus,
Extensor longus digitorum,
Extensor proprius pollicis,
Anterior tibial nerve.

Inner Side.		*Outer Side.*
Tibialis anticus, Tendon of extensor proprius pollicis.	**Anterior Tibial Artery.**	Anterior tibial nerve, Extensor longus digitorum, Extensor proprius pollicis, Tendons of extensor longus digitorum.

Behind.

Interosseous membrane,
Tibia (lower fourth),
Ankle-joint.

Branches.—The branches of the anterior tibial artery are the—

Recurrent,	External malleolar,
Muscular,	Internal malleolar.

The **recurrent branch** (anterior tibial recurrent) passes upwards beneath the origin of the tibialis anticus muscle to the front of the knee-joint, upon which it is distributed, anastomosing with the articular branches of the *popliteal artery.*

The **muscular branches** are numerous; they supply the muscles of the anterior tibial region. Some of them pass through the interosseous membrane to the muscles of the back of the leg and anastomose with branches of the posterior tibial and peroneal.

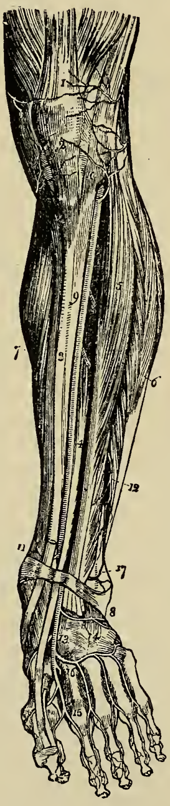


FIG. 250.—Anterior aspect of the leg and foot, showing the anterior tibial and dorsalis pedis arteries; the tibialis anticus has been removed. 1. Tendon of insertion of the quadriceps extensor muscle. 2. Insertion of the ligamentum patellæ into the lower border of the patella. 3. Tibia. 4. Extensor proprius pollicis muscle. 5. Extensor longus digitorum. 6. The peronei. 7. Inner belly of the gastrocnemius and soleus. 8. Annular ligament. 9. Anterior tibial artery. 10. Its recurrent branch inosculating with (2) inferior external articular, and (1) superior external articular arteries, branches of the popliteal. 11. Internal malleolar artery. 17. External malleolar inosculating with the anterior peroneal artery (12). 13. Dorsalis pedis artery. 14. Tarsal and metatarsal branches. 15. Dorsalis hallucis artery. 16. Continuation of the dorsalis pedis into the sole of the foot.

The **malleolar arteries** are distributed to the ankle-joint; the *external*, passing beneath the tendons of the extensor longus digitorum and peroneus tertius, inosculates with the anterior peroneal artery and dorsalis pedis; the *internal*, beneath the tendons of the extensor proprius pollicis and tibialis anticus, inosculates with branches of the posterior tibial and internal plantar artery. They supply branches to the ankle-joint.

The **DORSALIS PEDIS ARTERY** is continued forward along the tibial side of the dorsum of the foot, from the ankle to the base of the metatarsal bone of the great toe, where it divides into two branches, one of which dips between the two heads of the first dorsal interosseous muscle into the sole of the foot, and becomes continuous

with the deep plantar arch; the other, called **dorsalis hallucis**, runs forwards in the first interosseous space.

Relations.—The dorsalis pedis is situated along the outer border of the tendon of the extensor proprius pollicis; at its fibular side is the innermost tendon of the extensor longus digitorum, and near its termination, it is crossed by the inner tendon of the extensor brevis digitorum. It is accompanied by venæ comites, and has the continuation of the anterior tibial nerve to its outer side.

Plan of the **Relations** of the Dorsalis Pedis Artery.

	In Front. Integument, Deep fascia, Inner tendon of extensor brevis digitorum.	
Inner Side. Tendon of extensor proprius pollicis.	**Dorsalis Pedis Artery.**	*Outer Side.* Tendon of extensor longus digitorum, Border of extensor brevis digitorum, Anterior tibial nerve.
	Behind. Bones and ligaments of the tarsus.	

Branches.—The branches of this artery are the—

Tarsal,	Dorsalis hallucis,
Metatarsal,	Magna pollicis.

The **tarsal** branch arches transversely across the tarsus, beneath the extensor brevis digitorum muscle, and supplies the articulations of the tarsal bones and outer side of the foot; it anastomoses with the external malleolar, peroneal arteries, and external plantar.

The **metatarsal** forms an arch across the base of the metatarsal bones, and supplies the outer side of the foot, anastomosing with the tarsal and external plantar artery. From its convex side the metatarsal gives off three branches, *dorsal interosseous*, which pass forward upon the dorsal interosseous muscles, and divide into branches (*dorsal collateral*) for the supply of the sides of the toes between which they are placed. At their commencement these interosseous branches receive the posterior perforating arteries from the plantar arch, and opposite the heads of the metatarsal bones are joined by the anterior perforating branches from the digital arteries. The interosseous artery of the fourth interosseous space, in addition to the two dorsal collateral branches into which it bifurcates, sends a third branch to the outer side of the little toe.

The **dorsalis hallucis** runs forward upon the first dorsal interosseous muscle, and at the base of the first phalanx divides into two branches, one of which passes inwards beneath the tendon of the extensor proprius pollicis, and is distributed to the inner border of

PLATE 25.

THE FRONT OF THE LEG AND SOLE OF THE FOOT.

Fig. 1.

A. Tibialis anticus.
a, a. Its tendon.
B. Extensor longus digitorum.
b, b. Its tendons.
C. Extensor longus pollicis.
c, c. Its tendon.
F, F. Peroneus longus.
G, G. Peroneus brevis.
H, H. Deep fascia covering muscles and fibula.
K. Extensor brevis digitorum.
L. Anterior tibial artery and nerve.

Fig. 2.

A. Calcaneum.
B. Plantar fascia.
C. Abductor minimi digiti.
D. Abductor pollicis.
E. Flexor accessorius.
F. Flexor longus digitorum.
G. Flexor longus pollicis.
H. Flexor brevis pollicis.
i. Lumbricales.
L. External plantar artery and nerve.
M. Internal plantar artery and nerve.

Fig. 3.

H. Metatarsal bone of great toe.
i. Tendon of tibialis posticus.
K. External plantar nerve.
L. External plantar artery.
M. Interosseous muscles.
P. Tendon of peroneus longus.

The other references are the same as in fig. 2.

PLATE 25.

Fig. 1

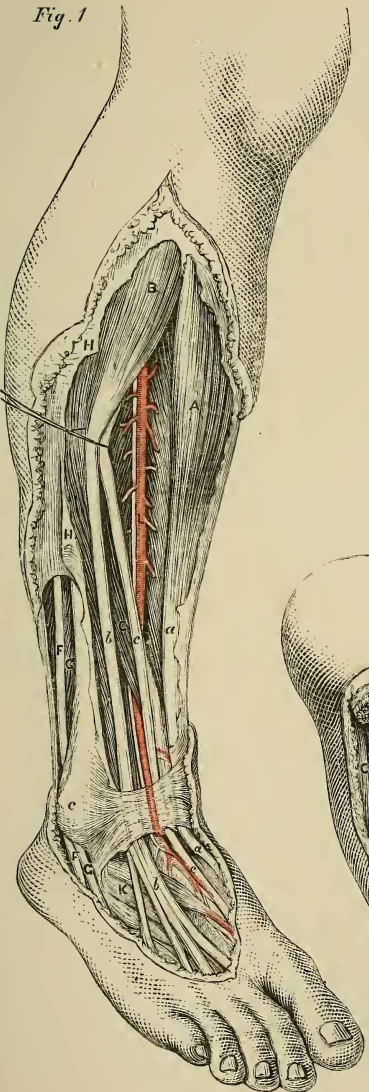


Fig. 2

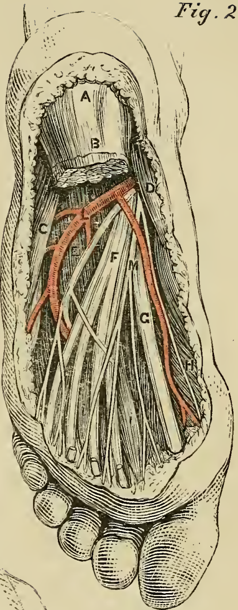
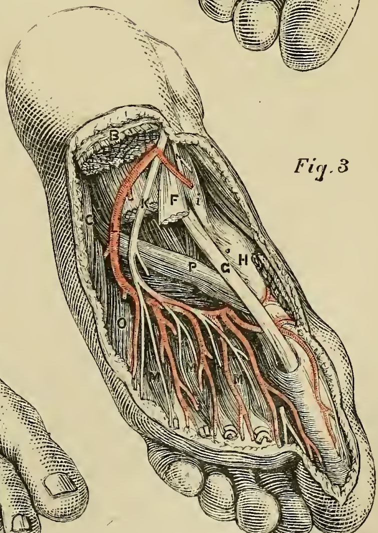


Fig. 3



the great toe, while the other bifurcates into two *dorsal collateral digital* branches for the adjacent sides of the great and second toe.

The **arteria magna pollicis** arises from the dorsalis pedis, while in the metatarsal space and just before its inosculation with the external plantar artery. It sends a *digital* branch to the inner border of the great toe on its plantar aspect, and bifurcates to supply the *plantar collateral digital branches* of the great and second toe.

POSTERIOR TIBIAL ARTERY.

The posterior tibial artery passes obliquely downwards along the tibial side of the leg from the lower border of the popliteus muscle to the concavity of the os calcis, where it divides into the internal and external plantar artery.

Relations.—In its course it lies first on the tibialis posticus, next on the flexor longus digitorum, then on the tibia; it is covered in by the intermuscular fascia which separates it above from the soleus, below from the deep fascia and integument. It is accompanied by venæ comites, and by the posterior tibial nerve, which lies to its inner side at first, and to its outer side for the rest of its course.

Plan of the **Relations** of the Posterior Tibial Artery.

Superficially.
Soleus,
Deep fascia,
Intermuscular fascia.

Inner Side.		*Outer Side.*
Posterior tibial nerve (upper third), Vein.	**Posterior Tibial Artery.**	Posterior tibial nerve (lower two-thirds), Vein.

Deeply.
Tibialis posticus,
Flexor longus digitorum,
Tibia,
Ankle-joint.

Branches.—The branches of the posterior tibial artery are the—

Peroneal,	Internal calcanean,
Nutrient,	Internal plantar,
Muscular,	External plantar.

The **PERONEAL ARTERY** is given off from the posterior tibial at about an inch below the lower border of the popliteus muscle; it is nearly as large as the anterior tibial artery, and passes obliquely outwards to the fibula. It then runs downwards along the inner border of the fibula to its lower third, where it divides into the anterior and posterior peroneal.

Relations.—The peroneal artery rests on the tibialis posticus

muscle, and is covered in by the soleus, intermuscular fascia, and flexor longus pollicis, having the fibula to its outer side.

Branches.—The branches of the peroneal artery are—*muscular* to the soleus and neighbouring muscles ; *nutrient* to the fibula ; and two terminal branches anterior and posterior peroneal.

The **anterior peroneal artery** pierces the interosseous membrane at the lower third of the leg, and is distributed on the front of the outer malleolus, anastomosing with the external malleolar and tarsal arteries.

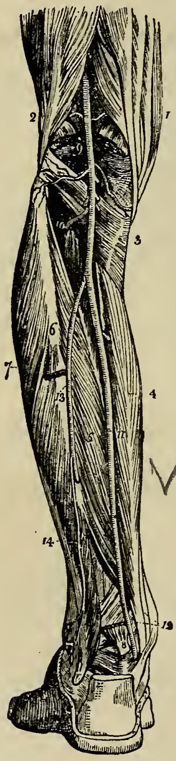


Fig. 251.—Posterior view of the leg, showing the popliteal and posterior tibial arteries. 1. Tendons of the inner hamstring. 2. Tendon of the biceps, forming the outer hamstring. 3. Popliteus muscle. 4. Flexor longus digitorum. 5. Tibialis posticus. 6. The fibula ; immediately below the figure is the origin of the flexor longus pollicis ; the muscle has been removed in order to expose the peroneal artery. 7. Peronei muscles, longus and brevis. 8. Lower part of the flexor longus pollicis muscle with its tendon. 9. Popliteal artery giving off articular and muscular branches ; the two superior articular are seen in the upper part of the popliteal space passing above the two heads of the gastrocnemius muscle, which are cut through near their origin. The two inferior are in relation with the popliteus muscle. 10. Anterior tibial artery passing through the angular interspace between the two heads of the tibialis posticus muscle. 11. Posterior tibial artery. 12. The relative position of the tendons and artery at the inner ankle from within outwards, previously to their passing beneath the internal annular ligament. 13. Peroneal artery, dividing a little below the figure, into two branches ; the anterior peroneal is seen piercing the interosseous membrane. 14. Posterior peroneal.

The **posterior peroneal** continues onwards along the posterior aspect of the outer malleolus to the side of the os calcis, to which and to the muscles arising from it, it distributes *external calcanean* branches. It anastomoses with the anterior peroneal, tarsal, external plantar, and posterior tibial artery ; with the latter by means of a small transverse branch (ramus anastomoticus transversus).

The **nutrient artery** of the tibia arises from the trunk of the posterior tibial, frequently above the origin of the peroneal, and proceeds to the nutrient canal, which it traverses obliquely from above downwards. It is the largest nutrient artery of bone in the body.

The **muscular branches** of the posterior tibial artery are distributed to the soleus and deep muscles of the posterior aspect of the leg. One of these branches is deserving of notice, a *recurrent branch*, which arises from the posterior tibial above the origin of the peroneal artery, pierces the soleus, and is distributed on the inner side of the head of the tibia, anastomosing with the inferior internal articular.

The **internal calcanean branches**, three or four in number, proceed from the posterior tibial artery immediately before its division; they are distributed to the integument, to the inner side of the os calcis, and to the muscles which arise from its inner tuberosity; and anastomose with the external calcanean branches of the posterior peroneal, and with all the neighbouring arteries, forming around the heel a network of inosculations, *rete calcaneum.*

PLANTAR ARTERIES.

The **internal plantar artery** proceeds from the bifurcation of the posterior tibial at the inner malleolus, and passes along the inner border of the foot beneath the abductor pollicis, supplying the inner border of the foot and great toe, and anastomosing with the digital branches distributed to the latter.

The **external plantar artery**, much larger than the internal, passes obliquely outwards between the first and second layer of the plantar muscles to the fourth metatarsal space. It then turns transversely inwards between the second and third layer, to the first metatarsal space, where it inosculates with the dorsalis pedis. The transverse portion of the artery describes a slight curve, having the convexity forwards; this is the *plantar arch.*

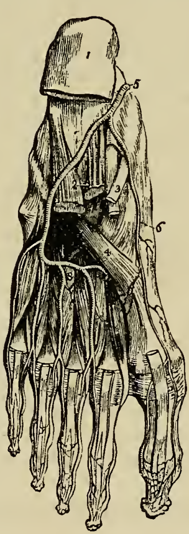


Fig. 252.—Arteries of the sole of the foot, the first and part of the second layer of muscles having been removed. 1. Under and posterior part of the os calcis; to which the origins of the first layer of muscles remain attached. 2. Musculus accessorius. 3. Long flexor tendons. 4. Tendon of the peroneus longus. 5. Termination of the posterior tibial artery. 6. Internal plantar. 7. External plantar artery. 8. The plantar arch giving off four digital branches, which pass forwards on the interossei muscles. Three of these arteries are seen dividing, near the heads of the metatarsal bones, into collateral branches for adjoining toes.

Branches.—The branches of the external plantar artery are the—

Muscular,
Articular,
Digital, { collateral, anterior perforating.
Posterior perforating.

The **muscular** and **articular branches** are distributed to the muscles of the sole of the foot and to the articulations of the tarsus.

The **digital branches** are four in number; the first is distributed to the outer side of the little toe; the three others pass forward to the cleft between the toes, and divide into *collateral branches*, which supply the adjacent sides of the three external toes, and the outer

side of the second. At the bifurcation of the toes, a small branch is sent upwards from each digital artery, to inosculate with the dorsal interosseous branches of the metatarsal; these are the *anterior perforating* arteries.

√ The **posterior perforating** are three small branches which pass upwards between the heads of the three external dorsal interosseous muscles, to inosculate with the arch formed by the metatarsal artery.

Varieties in the Arteries of the Lower Extremity.—The femoral artery occasionally divides at Poupart's ligament into two branches, and sometimes into three; the former is an instance of the high division of the profunda artery; and in the latter the branches are the profunda, superficial femoral, and internal circumflex. The point of origin of the profunda artery varies considerably in different subjects, being sometimes nearer to and sometimes farther from Poupart's ligament, but more frequently the former. The branches of the popliteal artery are very liable to variety in size; and in all these cases the compensating principle, so constant in the vascular system, is manifested. When the anterior tibial is of small size, the peroneal is large; and in place of dividing into two terminal branches at the lower third of the leg, descends to the lower part of the interosseous membrane, and emerges upon the front of the ankle, to supply the dorsum of the foot, or the posterior tibial and plantar arteries are large, and the external plantar is continued between the heads of the first dorsal interosseous muscle, to be distributed to the dorsal surface of the foot. Sometimes the posterior tibial artery is small and thread-like; and the peroneal, after descending to the ankle, curves inwards to the inner malleolus, and divides into two plantar arteries. If, in this case, the posterior tibial be sufficiently large to reach the ankle, it inosculates with the peroneal previously to the division of the latter. The internal plantar artery sometimes takes the distribution of the external plantar, which is short, and diminutive, and the latter not unfrequently replaces a deficient dorsalis pedis.

PULMONARY ARTERY.

The pulmonary artery has no connection with the general arterial distribution, but forms part of the lesser or pulmonary circulation. It is called an artery because it is engaged in conveying blood from the heart, but it must not be forgotten that it carries impure or venous blood from the right side of the heart to the lungs. It arises from the left side of the base of the right ventricle in front of the origin of the aorta, and ascends obliquely for the space of two inches to the under surface of the arch of the aorta, where it divides into the right and left pulmonary artery. In its course upwards and backwards it inclines to the left side, crossing the commencement of the aorta, and is connected by its left branch to the under surface of the arch by a thick and impervious cord, the remains of the **ductus arteriosus** of the fœtus.

Relations.—It is enclosed for nearly the whole of its extent by the pericardium, and receives the attachment of the fibrous portion of that membrane by its upper portion. Behind, it rests against the ascending portion of the arch of the aorta and left auricle, on either side is the appendix of the corresponding auricle with a coronary artery; and above, the superficial cardiac plexus, and the cord of the ductus arteriosus.

The **right pulmonary artery**, longer and somewhat larger than the left, passes transversely outwards behind the ascending aorta and superior vena cava to the root of the right lung, where it divides into two branches, the lower supplying the lower lobe, and the upper the other two lobes. In its course it lies parallel with and in front of the right bronchus.

The **left pulmonary artery**, shorter and smaller than the right, crosses the descending aorta and left bronchus to the root of the left lung, where it divides into two branches for the two lobes.

The pulmonary arteries divide and subdivide in the structure of the lungs, and terminate in capillary vessels which form a network around the air-passages and cells, and become continuous with the radicles of the pulmonary veins.

Relations.—In the root of the *right lung*, examined from above downwards, the pulmonary artery is situated between the bronchus and pulmonary veins, the former being above, the latter below: in the root of the *left lung* the artery is highest, next the bronchus, and then the veins. On both sides from before backwards, the artery is situated between the veins and bronchi, the former being in front, the latter behind.

VEINS.

The veins are the vessels which carry the blood back from the capillaries to the heart. They are larger, more numerous, and anastomose more freely than the arteries, and form two great systems of vessels, the superficial and the deep, the former lying between the superficial and deep layers of the superficial fascia, and the latter accompanying the arteries in their distribution; the two systems have very numerous communications.

The *portal system* of veins includes those belonging to the spleen, stomach, large and small intestine, and pancreas; its vessels differ from veins in general in being devoid of valves, in terminating as well as commencing in capillaries, and in the great thickness of their muscular coat. After the blood contained in the portal vein has been distributed to the liver, it is collected into a second series of veins, called *hepatic*, and by them conveyed into the inferior vena cava.

The veins will be described according to the primary division of the body, taking first, those of the head and neck; next, those of the upper extremity; then, those of the lower extremity; and lastly, the veins of the trunk.

VEINS OF THE HEAD AND NECK.

The veins of the head and neck may be arranged into three groups, namely, veins of the exterior of the head, veins of the diploë and interior of the cranium, veins of the neck.

The veins of the exterior of the head are the—

Facial,	Temporo-maxillary,
Internal maxillary,	Posterior auricular,
Temporal,	Occipital.

The **facial vein** commences on the anterior part of the head in a venous plexus, formed by the communications of the branches of the temporal, and descends along the middle line of the forehead, under the name of *frontal vein*, to the root of the nose, where it is connected with its fellow of the opposite side by a communicating trunk, the *nasal arch.* There are usually two frontal veins, which communicate by a transverse inosculation; but sometimes the vein is single and bifurcates at the root of the nose into the two angular veins. From the nasal arch the frontal is continued downwards by the side of the root of the nose, and near the angle of the eye, under the name of *angular vein;* it then passes beneath the zygomatic muscles, becomes the facial vein, and descends along the anterior border of the masseter muscle, crossing the body of the lower jaw by the side of the facial artery, to the submaxillary gland, and from thence to the internal jugular vein, in which it terminates.

FIG. 253.—Superficial veins of the head and neck. 1. Facial. 2. Temporal. 3. Transverse facial. 4. Posterior auricular. 5. Internal maxillary. 6. External jugular. 7. Posterior external jugular. 8. Anterior jugular. 9. Posterior scapular. 10. Internal jugular. 11. Occipital. 12. Subclavian.

The *branches* which the facial vein receives in its course are—the *supraorbital*, which joins the frontal vein; the *dorsal veins* of the nose, which terminate in the nasal arch; the *ophthalmic*, which communicates with the angular vein; the *palpebral* and *nasal*, which open into the angular vein; a considerable trunk, the *deep facial*, which returns the blood

from the spheno-maxillary fossa, from the infraorbital, palatine, Vidian, and spheno-palatine veins, and joins the facial beneath the zygomatic process of the superior maxillary bone; and the veins corresponding with the branches of the facial artery. It receives also a *communicating* branch from the temporo-maxillary, given off from that trunk near the angle of the jaw.

The **internal maxillary vein** receives the veins from the zygomatic and pterygoid fossa, which correspond generally with the branches of the internal maxillary artery; they are so numerous and communicate so freely as to constitute a *pterygoid plexus*, which is placed between the temporal and external pterygoid muscles. This plexus sends a small branch through the foramen Vesalii to join the cavernous sinus. Passing backwards behind the neck of the lower jaw, the internal maxillary joins the temporal to form the temporo-maxillary vein.

The **temporal vein** commences on the vertex of the head by a plexiform network, which is continuous with the frontal, opposite temporal, auricular, and occipital vein. The ramifications of this plexus form an anterior and posterior branch which unite immediately above the zygoma; the trunk is here joined by another large vein, the *middle temporal*, which collects the blood from the temporal muscle and outer segment of the orbit, and pierces the temporal fascia near the root of the zygoma. The temporal vein then descends in the substance of the parotid gland and a little below the neck of the lower jaw joins with the internal maxillary to form the temporo-maxillary vein. The temporal vein receives the *anterior auricular*, *masseteric*, *transverse facial*, and *parotid veins.*

The **temporo-maxillary vein**, a short trunk formed by the union of the temporal and internal maxillary, passes downwards in the substance of the parotid gland, lying in front of the external carotid artery; near the angle of the jaw it divides into two branches, one of which passes over the surface of the sterno-mastoid to form the external jugular, the other joins the facial vein, and forms with it a common trunk which ends in the internal jugular.

The **posterior auricular vein** communicates with the plexus of the vertex of the head, and descends behind the ear to join the external jugular vein near its origin. It receives in its course the veins of the external ear and the *stylo-mastoid vein.*

The **occipital vein**, commencing posteriorly in the plexus of the vertex of the head, follows the direction of the occipital artery, and passing deeply beneath the muscles of the back part of the neck, terminates in the external or internal jugular vein. This vein communicates with the lateral sinus by means of a large branch which passes through the mastoid foramen, the *mastoid vein.*

VEINS OF THE DIPLOË.

The diploë of the bones of the head is furnished in the adult with irregular sinuses (*venæ diploeticæ*), which are formed by a continua-

tion of the internal coat of the veins into the osseous canals in which they are lodged. At the middle period of life these sinuses are confined to separate bones; but in old age, after the ossification of the sutures, they may be traced from one bone to the next. They receive their blood from the capillaries supplying the cellular structure of the diploë, and terminate externally in the veins of the pericranium, internally, in the veins and sinuses of the dura mater; they are separated from the bony walls of the canals by a thin layer of medulla.

Four of these diploetic veins can be generally distinguished, namely, frontal, anterior temporal, posterior temporal, and occipital. The *frontal*, the smallest of the four, escapes from the frontal bone at the supraorbital notch, and opens into the supraorbital vein. The *anterior temporal* also collects the blood from the frontal bone, and terminates either in the deep temporal veins or in the cavernous

FIG. 254.—The external table of the skull removed to show the veins of the cranial diploë.

sinus, by passing through an opening in the great wing of the sphenoid. The *posterior temporal* commences in the parietal bone, and opens through an aperture in that bone into the lateral sinus, sometimes sending a branch outwards to the veins of the scalp. The *occipital*, the largest of the four, originates in the occipital bone, and terminates in the occipital sinus, or externally in the occipital vein.

CEREBRAL AND CEREBELLAR VEINS.

The cerebral veins are remarkable for the absence of valves, and for the extreme tenuity of their coats. They may be arranged into the superficial, and deep or ventricular veins.

The **superficial cerebral veins** are situated on the surface of the hemispheres lying in the grooves formed by the convexities of the convolutions. They are named from the position which they may chance to occupy on the surface of the brain, either superior or inferior, internal or external, anterior or posterior.

The **superior cerebral veins**, seven or eight in number at each side, pass obliquely forwards, and terminate in the superior longitudinal sinus, in the opposite direction to the course of the stream of blood in the sinus. In the infant the direction of these veins is nearly transverse.

The **deep** or **ventricular veins** commence within the lateral ventricles by the veins of the *corpora striata* and those of the *choroid plexuses*, which unite to form the two venæ Galeni.

The **venæ Galeni** pass backwards in the structure of the velum interpositum ; and escaping through the fissure of Bichât, terminate in the straight sinus.

The **cerebellar veins** are disposed, like those of the cerebrum, on the surface of the lobes of the cerebellum ; they are situated, some on the superior, some on the inferior surface, while others occupy the borders of the organ. Those in the middle line of the upper surface terminate in the veins of Galen and straight sinus ; those of the under surface in the lateral and occipital sinuses.

SINUSES OF THE DURA MATER.

The sinuses of the dura mater are irregular channels formed by the splitting of the layers of that membrane, and lined on their inner surface by a continuation of the internal coat of the veins. They are fifteen in number, five pairs and five single ones ; they may be divided into two groups—those situated at the upper and back part of the skull, and those of the base of the skull. The former are the—

Superior longitudinal sinus,	Occipital sinuses,
Inferior longitudinal sinus,	Lateral sinuses.
Straight sinus,	

The **superior longitudinal sinus** is situated in the attached margin of the falx cerebri, and extends along the middle line of the arch of the skull, from the foramen cæcum in the frontal, to the inner tuberosity of the occipital bone, where it terminates in the torcular Herophili. It is triangular in form, small in front, and increases gradually in size as it passes backwards ; it receives the superior cerebral veins which open into it obliquely, numerous small veins from the diploë, and near the posterior extremity of the sagittal suture the *parietal veins* from the pericranium and scalp. Examined in its interior, it presents numerous transverse fibrous bands (trabeculæ), the *chordæ Willisii*, which are stretched across its inferior angle ; and some small white granular masses, the *glandulæ Pacchioni;* the oblique openings of the cerebral veins, with their valve-like margin, are also seen on the walls of the sinus.

The termination of the superior longitudinal sinus forms a considerable dilatation, into which the straight sinus opens from the front, the lateral sinuses on each side, and the occipital sinuses from

below. This dilatation is named the **torcular Herophili**,* and is the point of communication of six sinuses, the superior longitudinal, two lateral, two occipital, and the straight. All the sinuses except the two lateral carry blood to the torcular, the latter carry it away.

The **inferior longitudinal sinus** is situated in the free margin of the falx cerebri; it is cylindrical in form, and extends from near the crista galli to the anterior border of the tentorium, where it terminates in the straight sinus. It receives in its course several veins from the falx and sometimes one or two from the internal surface of the hemispheres.

The **straight sinus** is the sinus of the tentorium; it is situated at the line of union of the falx with the tentorium; is prismoid in

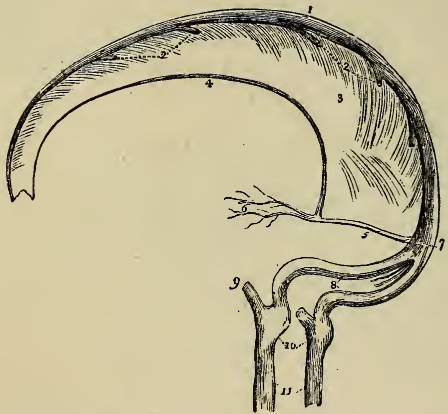


FIG. 255.—Sinuses of the upper and back part of the skull. 1. Superior longitudinal sinus. 2, 2. Cerebral veins opening into the sinus from behind forwards. 3. Falx cerebri. 4. Inferior longitudinal sinus. 5. Straight sinus. 6. Venæ Galeni. 7. Torcular Herophili. 8. The lateral sinuses, with the occipital sinuses between them. 9. The termination of the inferior petrosal sinus of one side. 10. Bulbs of the internal jugular veins, corresponding with the jugular fossæ. 11. Internal jugular veins.

form, and extends across the tentorium, from the termination of the inferior longitudinal sinus to the torcular Herophili. Besides the inferior longitudinal sinus it receives the venæ Galeni, the cerebral veins from the inferior part of the posterior lobes, and the superior cerebellar veins.

The **occipital sinuses** are two canals of small size, situated in the attached border of the falx cerebelli; they commence by several small veins around the foramen magnum, and terminate by separate openings in the torcular Herophili. They communicate with the posterior spinal veins, and not unfrequently with the termination of the lateral sinuses.

The **lateral sinuses**, commencing at the torcular Herophili, pass horizontally outwards, in the attached margin of the tentorium, and then curve downwards and inwards along the base of the petrous portion of the temporal bone, at each side, to the jugular foramina,

* *Torcular*, a press, from a supposition entertained by the older anatomists that the columns of blood, coming in different directions, compressed each other at this point; it is scarcely necessary to say that this notion was erroneous.

where they terminate in the internal jugular veins. Each sinus rests in its course on the transverse groove of the occipital bone, posterior inferior angle of the parietal, mastoid portion of the temporal, and again on the occipital bone. They receive the cerebral veins from the inferior surface of the posterior lobes, the inferior cerebellar veins, superior petrosal sinuses, mastoid and posterior condylar vein, and often the veins from the occipital diploë. These sinuses are often unequal in size, the right being larger than the left.

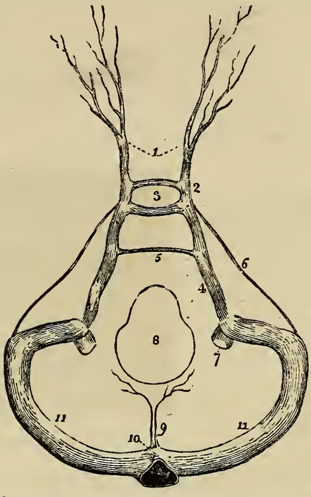


FIG. 256.—Sinuses of the base of the skull. 1. Ophthalmic veins. 2. Cavernous sinus of one side. 3. Circular sinus; the figure occupies the position of the pituitary gland in the sella turcica. 4. Inferior petrosal sinus. 5. Transverse sinus. 6. Superior petrosal sinus. 7. Internal jugular vein. 8. Foramen magnum. 9. Occipital sinuses. 10. Torcular Herophili. 11, 11. Lateral sinuses.

The sinuses of the base of the skull are the—

Cavernous,
Inferior petrosal,
Circular,
Superior petrosal,
Transverse.

The **cavernous sinuses** are named from presenting in their interior a reticular structure similar to that of the corpus cavernosum penis. They are situated at each side of the sella turcica, receiving, anteriorly, the ophthalmic veins through the sphenoidal fissures, and terminating posteriorly in the inferior petrosal sinuses. In the walls of the cavernous sinus are the internal carotid

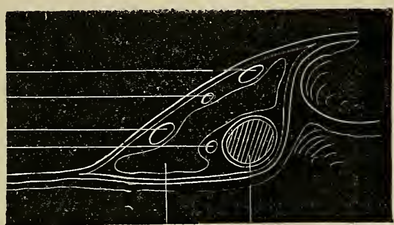


FIG. 257.—Diagram of left cavernous sinus seen in section from behind.

artery, several filaments of the carotid plexus, the third, fourth,

ophthalmic division of the fifth, and sixth nerve. The third, fourth, and ophthalmic nerves lie in the outer wall of the sinus, just beneath the dura mater; the sixth in the inner wall, between the sinus and the internal carotid artery. As the nerves approach the sphenoidal fissure they change their position, so that at that opening the fourth nerve is highest, next, the frontal and lachrymal branches of the ophthalmic, then the upper division of the third, the nasal branch

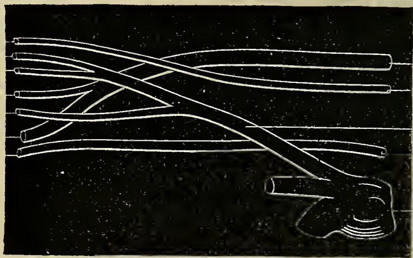


FIG. 258.—Diagram of the nerves passing through the cavernous sinus.

of the ophthalmic, the lower division of the third, and the sixth nerves, in the order here given. The artery and nerves are separated from the blood flowing through the sinus, by the lining membrane of the latter. Besides the ophthalmic vein the cavernous sinus receives the cerebral veins of the under part of the anterior lobe, a vein from the posterior border of the orbit and the vein of the middle fossa of the cranium. The cavernous sinuses communicate by means of the ophthalmic with the facial veins, by the circular sinus with each other, and by the superior petrosal with the lateral sinuses.

The **inferior petrosal sinuses** are the continuations of the cavernous sinuses backwards along the lower border of the petrous portion of the temporal bone at each side of the base of the skull, to the jugular foramina, where they terminate with the lateral sinuses in the commencement of the internal jugular veins.

The **circular sinus** is situated in the sella turcica, surrounding the pituitary gland, and communicating on each side with the cavernous sinus. It receives veins from the pituitary body, the dura mater, and the bone. The posterior segment is larger than the anterior.

The **superior petrosal sinuses** pass obliquely backwards along the attached border of the tentorium, on the upper margin of the petrous portion of the temporal bone, and establish a communication between the cavernous and lateral sinus at each side. They are of very small size, and receive one or two cerebral veins from the inferior part of the middle lobes, and a cerebellar vein from the anterior border of the cerebellum. Near the extremity of the petrous bone these sinuses cross the oval aperture which transmits the fifth nerve.

The **transverse sinus** passes transversely across the basilar process of the occipital bone, forming a communication between the two inferior petrosal sinuses. Sometimes there are two sinuses in this situation, or, more properly, a plexus.

VEINS OF THE NECK.

The veins of the neck which return the blood from the head are—

External jugular,	Internal jugular,
Anterior jugular,	Vertebral.

The **external jugular vein**, the continuation of the superficial division of the temporo-maxillary, augmented by the junction of the posterior auricular, and sometimes of the occipital, commences at the lower border of the parotid gland, in front of the sterno-mastoid muscle. It descends the neck in the direction of a line drawn from the angle of the lower jaw to the middle of the clavicle, crosses the sterno-mastoid, and terminates near the posterior and inferior attachment of that muscle, in the subclavian vein. It is provided with two pairs of valves, one situated near its entrance into the subclavian vein, and the other about the middle of the neck. In its course downwards, it lies on the anterior lamella of the deep cervical fascia, which separates it from the sterno-mastoid muscle, and is covered in by the platysma myoides and superficial fascia; at the root of the neck it pierces the deep cervical fascia. It is accompanied, for the upper half of its course, by the auricularis magnus nerve. The *branches* which it receives are the occipital cutaneous and posterior cervical cutaneous, and, near its termination, the supra-scapular and posterior scapular.

The external jugular vein is variable in size, and occasionally replaced by two veins.

The **anterior jugular vein** commences on the os hyoides by several small veins and by a branch from the temporo-maxillary, and passes downwards along the midline of the neck to the sternum; it then turns outwards behind the lower part of the sterno-mastoid and opens into the subclavian vein, near the termination of the external jugular. The two veins communicate with each other, and with the external and internal jugular vein. The anterior jugular is very variable in size, sometimes almost or entirely replacing the external jugular, and at others being represented only by a few small branches.

The **internal jugular vein**, formed by the convergence of the lateral and inferior petrosal sinus, commences at the foramen lacerum posterius on each side of the base of the skull, by a dilatation, and descends the side of the neck, lying, in the first instance, to the outer side of the internal carotid, then on the outer side of the common carotid artery to the root of the neck, where it unites with the subclavian, and constitutes the vena innominata. At its commencement, the internal jugular vein is posterior and external to the internal carotid artery and eighth pair of nerves, the hypoglossal

are 2 valves in internal jugular vein
but are not perfect [illegible]

nerve being behind it; lower down, the vein and artery are on the same plane, the glosso-pharyngeal and hypoglossal nerve passing forwards between them, the pneumogastric being between and behind in the same sheath, and the spinal accessory nerve, crossing obliquely behind or before the vein at its upper part. It is provided with a pair of valves, placed near its termination.

The **tributaries** which the internal jugular receives in its course are—*pharyngeal*, *occipital*, deep division of the *temporo-maxillary*, *facial*, and *middle thyroid*.

The **vertebral vein** descends by the side of the vertebral artery, in the canal formed by the foramina in the transverse processes of the cervical vertebræ, and at the root of the neck opens into the subclavian vein close to its termination. In the lower part of the vertebral canal it frequently divides into two branches, one of which advances forwards, while the other passes through the foramen in the transverse process of the seventh cervical vertebra, before opening into the subclavian vein.

The **tributaries** which it receives in its course are the *posterior condylar* vein, *muscular* veins, *cervical meningo-rachidian* veins, and near its termination the *superficial* and *deep cervical* veins.

The **inferior thyroid veins**, two, and frequently more in number, are situated one on each side of the trachea, and receive the venous blood from the thyroid gland. They communicate with each other, and with the middle and superior thyroid veins, and form a plexus on the front of the trachea. The right vein terminates in the right vena innominata, just at its union with the superior cava; the left in the left vena innominata.

VEINS OF THE UPPER EXTREMITY.

The veins of the upper extremity are deep and superficial. The *deep* veins accompany the branches and trunks of the arteries, and constitute their *venæ comites.* The venæ comites of the radial and ulnar artery are enclosed in the same sheath with those vessels, and terminate at the bend of the elbow in the brachial veins. The brachial venæ comites are situated one at each side of the artery, and open into the axillary vein; the axillary becomes the subclavian, and the subclavian unites with the internal jugular to form the vena innominata.

The **superficial veins** of the arm are the—

Anterior ulnar vein,	Cephalic vein,
Posterior ulnar vein,	Median vein,
Basilic vein,	Median basilic,
Radial vein,	Median cephalic.

The **anterior ulnar vein** collects the venous blood from the inner and palmar border of the hand, and ascends along the anterior aspect of the inner side of the forearm to the bend of the elbow, where it joins with the posterior ulnar to form the basilic vein.

The **posterior ulnar vein** commences on the dorsum of the hand by the ulnar termination of the *venous arch* which receives the *digital veins* from the fingers, and, after being joined by a large vein, the *vena salvatella*, from the little finger, ascends along the posterior aspect of the forearm to the bend of the elbow, where it turns forward and terminates by joining the anterior ulnar vein.

The **basilic vein** (βασιλικὸς, royal, or principal), formed by the union of the anterior and posterior ulnar veins, ascends along the inner side of the upper arm, receives the median basilic vein, and near its middle pierces the fascia; it then passes upwards to the axilla, and being joined by the brachial venæ comites, becomes the axillary vein.

The **radial vein** commences on the dorsum of the hand, by the radial termination of the *venous arch*, which receives the veins of the fingers. This origin is increased by the junction of some small veins from the thumb. The radial vein ascends the dorsal side of the forearm to a little below its middle, then lies on its anterior aspect to the bend of the elbow, where it receives the median cephalic, and becomes the cephalic vein.

The **cephalic vein** (κεφαλὴ, the head) ascends along the outer side of the upper arm to its superior third; it then enters the groove between the pectoralis major and deltoid muscle, where it is in relation with the descending branch of the thoracico - acromialis artery, pierces the costo-coracoid membrane, and terminates beneath the clavicle in the axillary vein. A large communicating branch sometimes crosses the clavicle between the external jugular and this vein, which gives it the appearance of being derived directly from the head—hence its appellation.

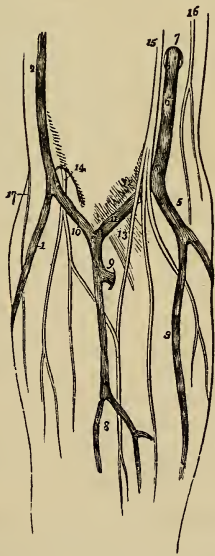
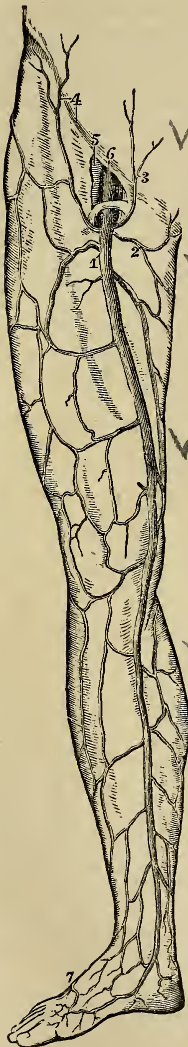


FIG. 259.—Veins of the forearm and bend of the elbow. 1. Radial vein. 2. Cephalic vein. 3. Anterior ulnar vein. 4. Posterior ulnar vein. 5. The trunk formed by their union. 6. Basilic vein, piercing the deep fascia at 7. 8. Median vein. 9. Communicating branch between the deep veins of the forearm and the upper part of the median vein. 10. Median cephalic vein. 11. Median basilic. 12. A slight convexity of the deep fascia, formed by the brachial artery. 13. The semilunar fascia of the biceps. 14. External cutaneous nerve. 15. Internal cutaneous nerve. 16. Intercosto - humeral nerve. 17. Spiral cutaneous nerve, a branch of the musculo-spiral.

The **median vein** is intermediate in position between the anterior ulnar and radial vein; it begins at the wrist by the junction of branches from the palm of the hand, and collects the blood from the



anterior aspect of the forearm, communicating with the two preceding. At the bend of the elbow it receives a branch from the deep veins, and divides into two branches, the median cephalic and median basilic.

The **median cephalic vein**, longer and somewhat smaller than the median basilic, passes obliquely outwards, in the groove between the biceps and supinator longus, to unite with the radial and form the cephalic vein. The branches of the external cutaneous nerve pass behind it.

The **median basilic vein**, larger than the median cephalic, passes obliquely inwards, in the groove between the biceps and pronator radii teres, and joins the basilic vein. This vein is crossed by one or two filaments of the internal cutaneous nerve, and overlies the brachial artery, from which it is separated by the semilunar fascia of the biceps.

AXILLARY VEIN.—The axillary vein is formed by the union of the venæ comites of the brachial artery with the basilic vein. It lies to the inner side of the artery, receives numerous branches from the collateral veins of the branches of the axillary artery, and at the lower border of the first rib becomes the subclavian vein. Above the pectoralis minor it receives the cephalic vein.

SUBCLAVIAN VEIN. — The subclavian vein crosses the first rib and beneath the clavicle, and unites with the internal jugular vein to form the vena innominata. It lies at first in front of the subclavian artery, and then in front of the scalenus anticus, which separates it from that vessel. The phrenic and pneumogastric nerve pass between the artery and vein. The veins opening into the subclavian are the external and anterior jugular externally to the scalenus anticus, and the vertebral internally to that muscle.

VEINS OF THE LOWER EXTREMITY.

The veins of the lower extremity are deep and superficial. The *deep veins* accompany the branches of the arteries in pairs, and form the venæ comites of the anterior and posterior

FIG. 260.—Superficial veins of the front of thigh and inner side of leg. 1. Internal saphena. 2. Superficial external pudic. 3. Superficial epigastric. 4. Superficial circumflex iliac. 5. Femoral artery. 6. Femoral vein. 7. Dorsal arch connecting the short and long saphena veins.

tibial and peroneal artery. These veins unite in the popliteal region to form a single vessel of large size, the popliteal, which successively becomes in its course the femoral and the external iliac vein.

POPLITEAL VEIN.—The popliteal vein ascends through the popliteal region, lying, in the first instance, superficial to the artery, and then getting somewhat to its outer side; and, passing through the oval opening in the tendon of the adductor magnus, becomes the femoral vein. It receives several muscular and articular branches, and the external saphena vein. The valves in this vein are four or five in number.

FEMORAL VEIN.—The femoral vein, commencing at the opening in the adductor magnus muscle, ascends the thigh in the sheath of the femoral artery, and entering the pelvis beneath Poupart's ligament, becomes the external iliac vein. In the lower part of its course it is situated on the outer side of the artery; it then becomes placed behind that vessel, and at Poupart's ligament, lies to its inner side. It receives the muscular veins and profunda, and, through the saphenous opening, the internal saphena vein. The valves in this vein are four or five in number.

The **profunda vein** is formed by the convergence of the numerous small veins which accompany the branches of the artery; it is a vein of large size, lies in front of the profunda artery and terminates in the femoral at about two inches below Poupart's ligament.

SUPERFICIAL VEINS. — The superficial veins are the external or short, and the internal or long saphena. They commence on the dorsum of the foot in a *venous arch* which lies across the metatarsus; this venous arch receives the *digital veins* by its convex side.

The **external saphena vein** commences at the outer extremity of the venous arch and on the outer border of the foot. It passes behind the outer ankle, ascends along the posterior aspect of the leg, lying in the groove between the two bellies of the gastrocnemius muscle, and pierces the deep fascia in the popliteal region to join the popliteal vein. It receives several cutaneous branches in the popliteal region previously to perforating the deep fascia, and is in relation in its course with the external saphenous nerve.

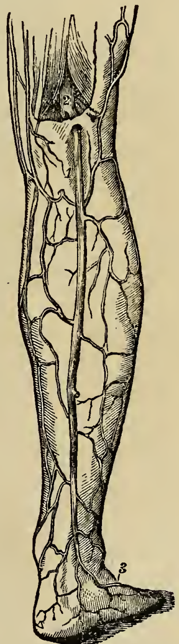


Fig. 261. — External saphena vein and its connections. 1. External saphena. 2. Popliteal. 3. Dorsal vein of the foot.

The **internal saphena vein** commences at the inner extremity of the venous arch of the dorsum and on the inner side of the foot and great toe. It ascends in front of the inner ankle and along the inner side of the leg; it then passes behind the inner condyle of the

femur and along the inner side of the thigh to the saphenous opening where it pierces the sheath of the femoral vessels, and terminates in the femoral vein, at about one inch and a half below Poupart's ligament.

It receives in its course the cutaneous veins of the leg and thigh, and communicates freely with the deep veins. At the saphenous opening it is joined by the superficial epigastric and circumflex iliac vein, and by the external pudics. The situation of this vein in the thigh is not unfrequently occupied by two or even three trunks of nearly equal size. It is accompanied in its course below the knee by the long saphenous nerve.

VEINS OF THE TRUNK.

The veins of the trunk may be divided into—1. The superior vena cava, with its formative branches. 2. The inferior vena cava, with its formative branches. 3. The azygos veins. 4. The vertebral and spinal veins. 5. The cardiac veins. 6. The portal vein. 7. The pulmonary veins.

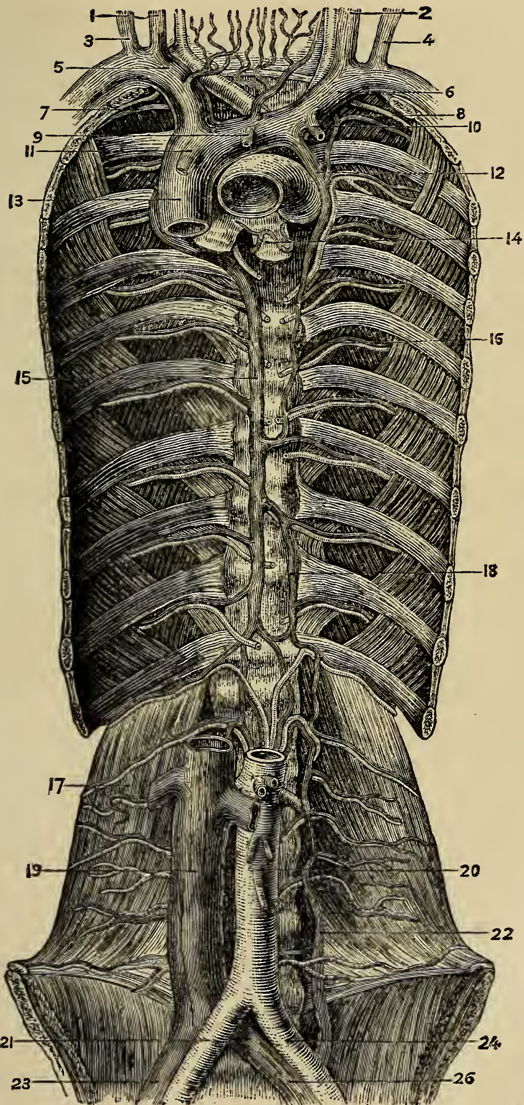
SUPERIOR VENA CAVA, WITH ITS FORMATIVE BRANCHES.

The **venæ innominatæ** are two large trunks, formed by the union of the internal jugular and subclavian vein at each side of the root of the neck.

The **right innominate** or **brachio-cephalic vein**, about an inch and a quarter in length, lies superficially and externally to the innominate artery, and descends almost vertically to unite with its fellow of the opposite side in the formation of the superior cava. It lies superficially to and on the right side of the arteria innominata, and has on its outer side the pleura and apex of the right lung. At the junction of the jugular and subclavian vein it receives from behind the ductus lymphaticus dexter, and lower down it has opening into it the *right internal mammary*, *right superior intercostal*, and *right inferior thyroid vein.*

The **left innominate** or **brachio-cephalic vein**, considerably longer than the right, extends almost horizontally across the roots of the three great arteries arising from the arch of the aorta to the right side of the mediastinum, where it unites with the right vena innominata, to constitute the superior vena cava.

FIG. 262.—Veins of the trunk. 1. Right internal jugular. 2. Left internal jugular. 3. Right external jugular. 4. Left external jugular. 5. Right innominate vein. 6. Left innominate. 7. Right superior intercostal vein. 8 and 12. Left superior intercostal veins. 9. Thymic vein. 10. Left internal mammary vein. 11. Pericardial and mediastinal veins. 13. Vena cava superior receiving vena azygos major. 14. Left bronchus. 15. Vena azygos major. 16. Superior vena azygos minor. 17. Quadratus lumborum. 18. Inferior vena azygos minor. 19. Vena cava inferior. 20. Abdominal aorta. 21. Right common iliac artery. 22. Communicating lumbar vein. 23. Right common iliac vein. 24. Left common iliac artery. 26. Left common iliac vein.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It is in relation in front with the left sterno-clavicular articulation, remains of the thymus gland, sterno-hyoid, and sterno-thyroid muscles, and first piece of the sternum. At its commencement it receives the thoracic duct which opens into it from behind, and in its course is joined by the *left inferior thyroid*, *left mammary*, and *left superior intercostal vein.* It also receives some small veins from the mediastinum and thymus gland. There are no valves in the venæ innominatæ.

veins close to heart have no valves

SUPERIOR VENA CAVA.

The superior cava (*descendens*) is a short trunk about three inches in length, formed by the junction of the two venæ innominatæ. It descends perpendicularly on the right side of the arch of the aorta, and entering the pericardium terminates in the upper part of the right auricle.

It is in relation *in front* with the pericardium ; *behind* with the right pulmonary artery ; *internally* with the ascending aorta ; *externally* with the pleura and right phrenic nerve. Immediately before entering the pericardium it receives the vena azygos major.

has no valves

INFERIOR VENA CAVA, WITH ITS FORMATIVE BRANCHES.

The **external iliac vein** lies to the inner side of the corresponding artery at the os pubis ; on the right side it gradually gets behind the artery as it passes upwards along the brim of the pelvis, but on the left side it lies altogether to the inner side of the artery ; it terminates opposite the sacro-iliac symphysis by uniting with the internal iliac, to form the common iliac vein. Immediately above Poupart's ligament it receives the epigastric and deep circumflex iliac vein ; it has no valves.

The **internal iliac vein** is formed by vessels which correspond with the branches of the internal iliac artery ; it receives the returning blood from the gluteal, ischiatic, internal pudic, and obturator vein, externally to the pelvis ; and from the vesical and uterine plexuses within the pelvis. The vein lies to the inner side of the internal iliac artery, and terminates by uniting with the external iliac vein, to form the common iliac.

The **vesical and prostatic plexus** is an important plexus of veins which surrounds the neck and base of the bladder and prostate gland, and receives its blood from the great *dorsal vein of the penis* and the veins of the external organs of generation. It is retained in connection with the sides of the bladder by a reflection of the pelvic fascia.

The **hæmorrhoidal plexus** consists of large veins with frequent anastomoses which surround the lower part of the rectum, beneath the mucous membrane. From the plexus proceed the superior, middle, and inferior hæmorrhoidal veins, which accompany the

arteries of the same name. This plexus forms a direct communication between the portal and general venous systems.

The **uterine plexus** is situated around the vagina, and at the sides of the uterus, between the two layers of the broad ligaments. The veins forming the vesical and uterine plexus are peculiarly subject to the production of calcareous concretions termed phlebolites.

The **common iliac veins** are formed by the union of the external and internal iliac vein at each side of the pelvis. The *right* common iliac, shorter than the left, ascends obliquely behind the corresponding artery; and on the intervertebral substance of the fourth and fifth lumbar vertebra, unites with the vein of the opposite side, to form the inferior cava. The *left* common iliac, longer and more oblique than the right, ascends behind and a little internally to the corresponding artery, and passes beneath the right common iliac artery, near its origin, to unite with the right vein in the formation of the inferior vena cava. Each common iliac vein receives the ilio-lumbar vein and often the lateral sacral; the left receives in addition the vena sacra media. These veins have no valves.

INFERIOR VENA CAVA.

The inferior vena cava is formed by the union of the two common iliac veins, on the intervertebral substance of the fourth and fifth lumbar vertebra. It ascends along the front of the vertebral column, to the right of the abdominal aorta, and passing through the fissure in the posterior border of the liver and the quadrilateral opening in the tendinous centre of the diaphragm, terminates in the inferior and posterior part of the right auricle. There are no valves in this vein.

It is in *relation* from below upwards, *in front* with the mesentery, transverse duodenum, portal vein, pancreas, and liver, which latter nearly and sometimes completely surrounds it; *behind* it rests on the vertebral column and right crus of the diaphragm, from which it is separated by the right renal artery and right lumbar arteries; to the *right* it has the peritoneum and sympathetic nerve; to the *left* the aorta.

The **tributaries** which the inferior vena cava receives in its course are the—

Lumbar,	Supra-renal,
Right spermatic,	Phrenic,
Renal,	Hepatic.

The **lumbar veins**, three or four in number at each side, collect the venous blood from the muscles and integument of the loins, and spinal veins: the left are longer than the right on account of the position of the vena cava, and pass behind the aorta in order to reach that vessel. These veins communicate with each other by branches which pass in front of the transverse processes of the vertebræ.

Spermatic veins have valves but not any account after the pampiniform plexus

The **right spermatic vein** is formed by the two veins which return the blood from the venous plexus of the spermatic cord. These veins follow the course of the spermatic artery, and unite to form the single trunk which opens into the inferior vena cava. The *left spermatic vein* terminates in the left renal vein.

The **ovarian veins** represent the spermatic veins of the male, and collect the venous blood from the ovaries, round ligaments, Fallopian tubes, and communicate with the uterine sinuses. They terminate as in the male.

The **renal** or **emulgent veins** return the blood from the kidneys; their branches are situated in front of the divisions of the renal arteries, and the left opens into the vena cava somewhat higher than the right. The *left* is longer than the right in consequence of the position of the vena cava, and crosses the aorta immediately below the origin of the superior mesenteric artery. It receives the *left spermatic vein*, which terminates in it at right angles: hence the more frequent occurrence of varicocele on the left than on the right side; it also receives the left inferior phrenic and left supra-renal.

The **supra-renal veins** terminate partly in the renal veins, and partly in the inferior vena cava.

The **phrenic veins** return the blood from the ramifications of the phrenic arteries; they open into the inferior vena cava.

The **hepatic veins** form two principal trunks and numerous smaller channels which open into the inferior vena cava, while that vessel is situated in the posterior border of the liver. The hepatic veins commence in the liver by minute venules, the *intralobular veins*, in the centre of each lobule; these pour their blood into larger vessels, the *sublobular veins*; and the sublobular veins constitute, by their convergence and union, the hepatic trunks, which terminate in the inferior vena cava.

AZYGOS VEINS.

The azygos veins (fig. 262) form a system of communication between the superior and inferior vena cava, and serve to return the blood from that part of the trunk of the body in which those vessels are deficient, on account of their connection with the heart. This system consists of five vessels, namely—

Vena azygos major,
Vena azygos minor superior,
Vena azygos minor inferior,
Two superior intercostal veins.

The **vena azygos major** commences in the lumbar region by a communication with the right lumbar veins; sometimes it is joined by a branch directly from the inferior vena cava, or by one from the renal vein. It passes through the aortic opening of the diaphragm, lying on the right side of the thoracic duct and aorta,

and ascends along the right side of the vertebral column to the third dorsal vertebra, where it arches forwards over the right bronchus, and terminates in the superior vena cava. It receives all the intercostal veins of the right side with the exception of those of the first and second space, the vena azygos minor superior and inferior, some œsophageal veins, and right bronchial vein.

The **vena azygos minor superior** is formed by the union of the intercostal veins of the left side from the fourth to the eighth; it communicates with the left superior intercostal vein, and crosses the body of the eighth dorsal vertebra behind the aorta to empty into the vena azygos major.

The **vena azygos minor inferior** commences in the lumbar region, on the left side, by a communication with one of the lumbar veins or with the renal vein. It enters the chest through the left crus of the diaphragm and ascends the left side of the vertebral column, crosses the ninth dorsal vertebra and opens into the vena azygos major. It receives the three lower intercostal veins of the left side.

The azygos veins have no valves.

The **right superior intercostal vein** receives the veins of the first, or first and second intercostal space, and opens into the innominate vein of the same side.

The **left superior intercostal vein** is the trunk formed by the union of the two or three upper intercostal veins of the left side. It communicates below with the vena azygos minor superior, and crosses the arch of the aorta to terminate in the left vena innominata. It receives the left bronchial vein.

VERTEBRAL AND SPINAL VEINS.

The numerous venous plexuses of the vertebral column and spinal cord may be arranged into four groups:—

1. Those ramifying on the arches of the vertebræ externally, *dorsi-spinal.*

2. Those situated within the vertebral canal between the vertebræ and the membranes, *meningo-rachidian.* These are further divisible into an anterior and a posterior set.

3. The veins of the bodies of the vertebræ, *venæ basis vertebrarum.*

4. The veins of the spinal cord, *medulli-spinal.*

1. The **dorsi-spinal veins** form a plexus around the spinous, transverse, and articular processes, and arches of the vertebræ. They receive the returning blood from the dorsal muscles and surrounding structures, and transmit it, in part to the veins inside the vertebral canal, by branches which perforate the ligamenta subflava, and in part to the vertebral, intercostal, lumbar, and sacral veins.

2. The **meningo-rachidian veins** are situated between the spinal dura mater and the vertebræ. They communicate freely with each

other by means of a complicated plexus. In front they form two longitudinal trunks (*anterior longitudinal spinal veins*), extending the whole length of the column on each side of the posterior common ligament, and are joined on the body of each vertebra by transverse trunks, which pass beneath the ligament, and receive the large basi-vertebral veins from the interior of each vertebra. The posterior trunks (*posterior longitudinal spinal veins*) are smaller than the anterior; they are situated one on each side between the laminæ and the theca vertebralis; they communicate with each other, with the anterior trunks, and with the dorsi-spinal veins. The meningo-rachidian veins communicate superiorly through the anterior condylar foramina with the internal jugulars; in the neck they pour their blood into the vertebral veins; in the thorax, into the inter-

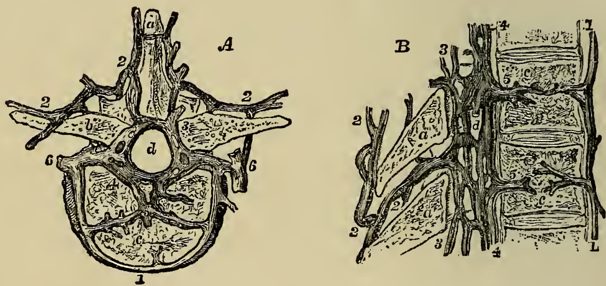


FIG. 263.—Vertebral and spinal veins. A. Horizontal view. B. Vertical view. *a*. Spinous process. *b*. Transverse process. *c*. Body of vertebra. *d*. Spinal canal. 1. Anterior external veins of body. 2. Posterior external veins of body (dorsal spinal). 3. Posterior internal veins (meningo-rachidian). 4. Anterior internal veins (meningo-rachidian). 5. Venæ basis vertebrarum. 6. Lateral vertebral veins.

costals; and in the loins and pelvis into the lumbar and sacral veins, the communications being made through the intervertebral foramina.

3. The **venæ basis vertebrarum** pass out through the large foramina in the posterior surfaces of the bodies of the vertebræ, and empty into the transverse branches of the anterior longitudinal spinal veins. They are contained in large tortuous channels in the substance of the bones, similar to those in the diploë of the skull, and run parallel with the upper and lower surfaces of the bodies of the vertebræ. The canals become greatly developed in old age.

4. The **medulli-spinal veins** are situated between the pia mater and arachnoid; they communicate freely with each other to form plexuses, and send branches through the intervertebral foramina with each of the spinal nerves, to join the veins of the trunk.

CARDIAC VEINS.

The veins (coronary) returning the blood from the substance of the heart are the—

Great cardiac vein,	Anterior cardiac veins,
Posterior cardiac vein,	Venæ Thebesii,
Coronary sinus.	

The **great cardiac vein** (vena cordis magna; coronaria magna) commences at the apex of the heart, and ascends along the anterior ventricular groove to the base of the ventricles; it then curves around the left auriculo-ventricular groove to the posterior part of the heart, where it terminates in the coronary sinus, its opening being guarded by a valve of two segments. It receives in its course the left cardiac veins from the left auricle and ventricle.

The **posterior cardiac vein** (vena cordis media), frequently two in number, commences also at the apex of the heart, and ascends along the posterior ventricular groove, to terminate in the coronary sinus. It receives the veins at right angles from the posterior aspect of the two ventricles.

The **anterior cardiac veins** (venæ parvæ) collect the blood from the anterior surface of the right ventricle; one larger than the rest runs along the right border of the heart and joins the trunk formed by these veins, which curves around the right auriculo-ventricular groove, to open directly into the auricle.

The **venæ Thebesii** (venæ minimæ) are numerous minute veins which convey the venous blood directly from the substance of the heart into the right auricle.

The **coronary sinus** is a short but wide trunk which forms the true continuation of the great cardiac vein. It is situated at the back of the heart between the left auricle and ventricle, and is covered by the muscular fibres of the auricle; it receives the great cardiac and posterior cardiac veins, and also a small vessel called the *oblique vein* which crosses the back of the left auricle. The coronary sinus opens into the back of the right auricle, the opening being guarded by a small fold of endocardium which receives the name of *coronary* or *Thebesian* valve. All the veins joining the sinus are guarded at their entrance by more or less complete valves, except the oblique vein.

PORTAL SYSTEM.

The portal system is composed of four large veins which return the blood from the chylopoietic viscera; they are the—

Inferior mesenteric vein,	Splenic vein,
Superior mesenteric vein,	Gastric veins.

The **inferior mesenteric vein** receives its blood from the rectum by means of the hæmorrhoidal veins, and from the sigmoid flexure and descending colon, and ascends behind the transverse duodenum

and pancreas, to terminate in the splenic vein. Its hæmorrhoidal branches inosculate with branches of the internal iliac vein, and thus establish a communication between the portal and general venous system.

The **superior mesenteric vein** is formed by branches which collect the venous blood from the capillaries of the superior mesenteric artery; they constitute by their junction a large trunk, which

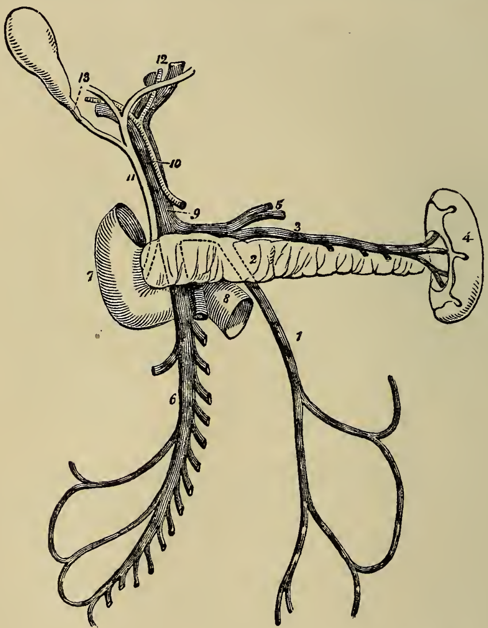


FIG. 264.—The portal vein. 1. Inferior mesenteric vein; it is traced by means of dotted lines behind the pancreas (2) to terminate in the splenic vein (3). 4. Spleen. 5. Branches from the stomach, opening into the splenic vein. 6. Superior mesenteric vein. 7. Descending portion of the duodenum. 8. Its transverse portion, crossed by the superior mesenteric vein and part of the trunk of the superior mesenteric artery. 9. Portal vein. 10. Hepatic artery. 11. Ductus communis choledochus. 12. Division of the duct and vessels at the transverse fissure of the liver. 13. Cystic duct leading to the gall-bladder.

ascends by the side of the corresponding artery, crosses the transverse portion of the duodenum, and unites behind the pancreas with the splenic in the formation of the portal vein.

The **splenic vein** commences in the structure of the spleen, and quits that organ by several large branches; it is larger than the splenic artery, and perfectly straight in its course. It passes horizontally inwards behind the pancreas, and terminates near its greater

end by uniting with the superior mesenteric and forming the portal vein. It receives in its course the vasa brevia, left gastro-epiploic, pancreatico-duodenal, and pancreatic veins, and near its termination the inferior mesenteric vein.

The **gastric veins** for the most part take the course of the corresponding arteries, those of the large end of the stomach terminating in the splenic vein, and the right gastro-epiploic in the superior mesenteric. Those along the lesser curvature are, however, differently arranged to the arteries; they are two in number, and receive the name of **coronary veins.** Of these the one placed most anteriorly is the smallest: it runs from the cardiac towards the pyloric end of the curve, receives branches from the pylorus and upper part of the duodenum, and ends in the portal vein. The posterior branch, much the largest, runs from the pyloric towards the cardiac end, and at about an inch and a half from the œsophagus winds to the posterior surface of the stomach, crosses the splenic artery, and terminates in the portal vein above the preceding.

The **VENA PORTÆ**, or portal vein, formed by the union of the splenic and superior mesenteric veins behind the pancreas, ascends through the right border of the lesser omentum to the transverse fissure of the liver, where it divides into two branches, one for each lateral lobe. In the right border of the lesser omentum it is situated behind and between the hepatic artery and ductus communis choledochus, and is surrounded by the hepatic plexus of nerves and lymphatics. At the transverse fissure each primary branch divides into numerous secondary branches which ramify through the portal canals, and give off vaginal and interlobular veins, and the latter terminate in the lobular venous plexus of the lobules of the liver. The portal vein within the liver receives the venous blood from the capillaries of the hepatic artery.

Communications with the Systemic Veins.—The veins forming the portal system communicate with those of the systemic system—(1) By the inosculation of the inferior hæmorrhoidal tributaries of the inferior mesenteric with those of the internal iliac; (2) by communications between the left renal vein and the veins of the intestines, especially those of the colon and duodenum; and (3) by the inosculation of superficial branches of the portal veins of the liver with the phrenic veins.

PULMONARY VEINS.

The pulmonary veins, four in number, return the arterial blood from the lungs to the left auricle of the heart; they differ from veins in general, in the area of their cylinders being but little larger than that of the corresponding arteries, in carrying arterial blood, in being devoid of valves, and in accompanying singly each branch of the pulmonary artery. They commence in the capillaries upon the parietes of the intercellular passages and air-cells, and unite to form a single trunk for each lobe. The vein of the middle lobe of the right

lung unites with the superior vein, so as to form the two trunks which open into the left auricle. Sometimes they remain separate, and then there are three pulmonary veins on the right side. The right pulmonary veins pass behind the right auricle to the left auricle; the left pass in front of the descending aorta; they both pierce the pericardium. Within the lung the branches of the pulmonary veins are behind the bronchial tubes, and those of the pulmonary artery in front; but at the root of the lungs the veins are in front, next the arteries, and then the bronchi.

LYMPHATICS.

Lymphatic vessels admit of a threefold division, into superficial, deep, and lacteals. The *superficial lymphatic vessels*, on the surface of the body, follow the course of the veins, and pierce the deep fascia in convenient situations, to join the deep lymphatics. On the surface of organs they converge to the nearest lymphatic trunks. The *superficial lymphatic glands* are placed in the most protected situations of the superficial fascia, as in the hollow of the ham and groin in the lower extremity; on the inner side of the arm in the upper extremity.

The *deep lymphatics*, fewer in number and somewhat larger than the superficial vessels, accompany the deeper veins; those from the lower parts of the body converging to the numerous glands seated around the iliac veins and inferior vena cava, and terminating in a large trunk situated on the vertebral column, the thoracic duct. From the upper part of the trunk of the body on the left side, and from the left side of the head and neck, they also proceed to the thoracic duct. Those on the right side of the head and neck, right upper extremity, and right side of the thorax, form a distinct duct which terminates at the point of junction of the subclavian with the internal jugular vein on the right side of the root of the neck.

The *lacteals* are the lymphatic vessels of the small intestines; they have received their distinctive appellation from conveying the milk-like product of digestion, the chyle, to the great centre of the lymphatic system, the thoracic duct. They are situated in the mesentery, and open into the numerous mesenteric glands in their course. When digestion is not proceeding they carry transparent lymph, like the other lymphatics.

The lymphatic vessels and glands will be described according to the arrangement adopted for the veins, commencing with those of the head and neck, and proceeding next to those of the upper extremity, lower extremity, and trunk.

LYMPHATICS OF THE HEAD AND NECK.

Glands.—The **superficial lymphatic glands of the head and face** are small, few in number, and isolated; they are—the *occipital*, which are situated near the origin of the occipito-frontalis muscle;

posterior auricular, behind the ear; *parotid*, on the parotid gland; *zygomatic*, in the zygomatic fossa; *buccal*, on the buccinator muscle, and *submaxillary*, beneath the margin of the lower jaw. There are no deep lymphatic glands within the cranium.

The **superficial cervical lymphatic glands** are few in number and small; they are situated in the course of the external jugular vein, between the sterno-mastoid and trapezius muscle, at the root of the neck, and about the larynx.

The **deep cervical glands** (glandulæ concatenatæ) are numerous and of large size; they are situated around the internal jugular vein and sheath of the carotid artery, by the side of the pharynx, œsophagus, and trachea, and extend from the base of the skull to the root of the neck, where they are in communication with the lymphatic vessels and glands of the thorax.

Vessels.—The **superficial lymphatic vessels of the head and face** are disposed in three groups: *occipital*, which take the course of the occipital vein to the occipital and deep cervical glands; *temporal*, which follow the branches of the temporal vein to the parotid and deep cervical glands; and *facial*, which accompany the facial vein to the submaxillary lymphatic glands.

Fig. 265.—Superficial lymphatic vessels and glands of the head and neck.

The **deep lymphatic vessels of the head** are the *meningeal* and *cerebral*; the former are situated in connection with the meningeal veins, and escape through foramina at the base of the skull, to join the deep cervical glands. The chief *cerebral lymphatics*, according to Fohmann, are situated on the surface of the pia mater. They pass most probably through the foramina at the base of the skull, to terminate in the deep cervical glands. In the substance of the brain the lymphatic capillaries form *perivascular spaces* or *canals* around all the blood-vessels even to their smallest ramifications, and are in communication with similar spaces in the pia mater, and with the sub-arachnoid space.

The **lymphatic vessels of the cranial cavity** are situated in the pia mater and arachnoid, and in the choroid plexuses of the lateral ventricles; they accompany the branches of the vertebral and

internal carotid arteries, and leave the cranial cavity by the foramina at its base to join the deep cervical lymphatics.

The **deep lymphatic vessels of the face** proceed from the nasal fossæ, mouth, and pharynx, and terminate in the submaxillary and deep cervical glands.

Fig. 266. — Superficial lymphatic vessels and glands of the arm and axilla.

The **superficial** and **deep cervical lymphatic vessels** accompany the jugular veins, passing from gland to gland; at the root of the neck they communicate with the thoracic lymphatic vessels, and terminate, on the right side, in the ductus lymphaticus dexter; on the left in the thoracic duct, near its termination.

LYMPHATICS OF THE UPPER EXTREMITY.

Glands. — The **superficial lymphatic glands** of the arm are not more than four or five in number, and of very small size. One or two are situated near the median basilic and median cephalic vein, at the bend of the elbow; and one or two near the basilic vein, on the inner side of the upper arm, immediately above the elbow.

The **deep glands** in the forearm are excessively small and infrequent; two or three may be found in the course of the radial and ulnar vessels. In the upper arm there is a chain of small glands, accompanying the brachial artery.

The **axillary glands** are numerous and of large size. Some are closely adherent to the vessels, others are dispersed in the loose cellular tissue of the axilla, and a small chain may be observed extending along the lower border of the pectoralis major to the mammary gland, receiving the lymphatics of that organ and of the front of the chest wall. A similar chain is found along the lower border of the posterior fold of the axilla; it receives the lymphatic vessels from the integument of the back. Two or three subclavian

glands are situated beneath the clavicle, and serve as the medium of communication between the axillary and deep cervical lymphatic glands.

VESSELS.—The **superficial lymphatic vessels** of the upper extremity commence on the fingers and take their course along the forearm to the bend of the elbow. The greater part reach their destination by passing along the dorsal surface of the fingers, wrist, and forearm, and then curving around the borders of the latter; but some few are met with in the palm of the hand, which take the direction of the median vein. At the bend of the elbow the lymphatics arrange themselves into two groups; an internal and larger group, which communicates with a gland situated just above the inner condyle, and then accompanies the basilic vein upwards to the axilla to enter the axillary glands; and a smaller group which follows the course of the cephalic vein. Several of the vessels of this group cross the biceps muscle at its upper part to reach the axillary glands, while the remainder, two or three in number, ascend with the cephalic vein in the interspace of the deltoid and pectoralis major; these latter usually join a small gland in this space and then cross the pectoralis minor muscle to become continuous with the subclavian lymphatics.

Besides the lymphatic vessels of the arm, the axillary glands receive those from the integument of the chest, its anterior, posterior, and lateral aspect, and the lymphatics of the mammary gland.

The **deep lymphatics** accompany the vessels of the upper extremity, and communicate occasionally with the superficial lymphatics. They enter the axillary and subclavian glands, and, at the root of the neck, terminate on the left side in the thoracic duct, and on the right side in the ductus lymphaticus dexter.

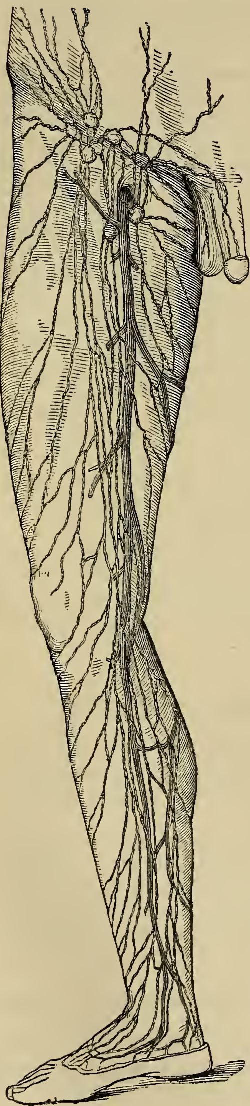
LYMPHATICS OF THE LOWER EXTREMITY.

GLANDS.—The **superficial lymphatic glands** of the lower extremity are those of the groin, *inguinal;* and one or two situated in the superficial fascia of the posterior aspect of the thigh, just above the popliteal region.

The **inguinal glands** are divisible into two groups; a superior group of small size, situated along the line of Poupart's ligament, and receiving the lymphatic vessels from the parietes of the abdomen, gluteal region, perineum, and genital organs; and an inferior group, called **femoral glands,** of larger glands clustered around the internal saphena vein near its termination, and receiving the superficial lymphatic vessels from the lower extremity.

The **deep lymphatic glands** are the *anterior tibial*, *popliteal*, *deep inguinal*, *gluteal*, and *ischiatic*.

The **anterior tibial** is generally a single gland, placed on the interosseous membrane, by the side of the anterior tibial artery in the upper part of its course.



The **popliteal glands**, four or five in number, and small, are embedded in the loose cellular tissue and fat of the popliteal space.

The **deep inguinal glands**, less numerous and smaller than the superficial, are situated near the femoral vessels in the groin, beneath the fascia lata; they communicate with the superficial lymphatics through the saphenous opening.

The **gluteal** and **ischiatic glands** are placed near the vessels of that name, above and below the pyriformis muscle at the great ischiatic foramen.

VESSELS.—The **superficial lymphatic vessels** are divisible into two groups, internal and external; the *internal* and principal group, commencing on the dorsum and inner side of the foot, ascend the leg by the side of the internal saphena vein, and, passing behind the inner condyle of the femur, follow the direction of that vein to the groin, where they join the femoral group of superficial inguinal glands. The greater part of the efferent vessels from these glands pierce the cribriform fascia of the saphenous opening and the sheath of the femoral vessels, to join the lymphatic gland situated in the femoral ring, which serves to establish a communication between the lymphatics of the lower extremity and those of the trunk. The other efferent vessels pierce the fascia lata to join the deep glands. The vessels which pass upwards from the outer side of the dorsum of the foot ascend along the outer side of the leg, and curve inwards across the front of the leg just below the knee, to unite with the lymphatics of the inner side of the thigh. The *external group* consists of a few lymphatic vessels which commence on the outer side of the foot and posterior part of the ankle, and accompany the external saphena vein to the popliteal region, where they enter the popliteal glands.

FIG. 267.—Superficial lymphatic vessels and glands of the front and inner side of the leg.

The **deep lymphatic vessels** accompany the deep veins, and communicate with the various glands in their course. After joining the deep inguinal glands they pass beneath Poupart's ligament, to communicate with the numerous glands situated around the iliac vessels. The deep lymphatics of the gluteal region follow the course of the branches of the gluteal and ischiatic veins. The former join the glands situated on the upper border of the pyriformis muscle, and the latter, after communicating with the lymphatics of the thigh, enter the ischiatic glands.

LYMPHATICS OF THE TRUNK.

The lymphatics of the trunk may be arranged under three heads, superficial, deep, and visceral.

The **superficial lymphatic vessels** of the upper half of the trunk pass upwards and outwards at each side, and converge, some to the axillary glands, others to the glands at the root of the neck. The lymphatics from the mammary glands follow the lower border of the pectoralis major, communicating, by means of a chain of lymphatic glands, with the axillary glands. The superficial lymphatic vessels of the lower half of the trunk, gluteal region, perineum, and external organs of generation, converge to the superior group of superficial inguinal glands. One or two small glands are situated at each side of the dorsal vein of the penis, near the suspensory ligament; from these, as from the superficial lymphatics, the efferent vessels pass into the superior group of superficial inguinal glands.

Glands.—The **deep lymphatic glands of the thorax** are the intercostal, anterior mediastinal, and œsophageal.

The **intercostal glands,** of small size, are situated on each side of the vertebral column, near the articulations of the heads of the ribs, and in the course of the intercostal arteries.

The **anterior mediastinal glands** are situated along the course of the internal mammary arteries; they are six or seven in number at each side, and receive the lymphatic vessels from the anterior wall of the chest, the mediastinum, thymus gland, and pericardium.

The **œsophageal** or **posterior mediastinal glands,** fifteen or twenty in number, are situated in the course of the œsophagus, and receive the lymphatics of that tube; they communicate above with the deep cervical glands, on each side with the intercostal, and below with the abdominal glands.

Vessels.—The **deep lymphatic vessels of the thorax** are the intercostal, internal mammary, and diaphragmatic.

The **intercostal** lymphatic vessels follow the course of the veins of the same name; and reaching the vertebral column, curve downwards, to terminate in the thoracic duct.

The **internal mammary** lymphatics commence in the parietes of the abdomen communicating with the epigastric lymphatics. They ascend by the side of the internal mammary vessels, being

joined in their course by thc anterior intercostals, and terminate at the root of the neck, on the right side in the tributaries of the ductus lymphaticus dexter; on the left, in the thoracic duct. The *diaphragmatic* lymphatics pursue the direction of their corresponding veins, and terminate, some *in front*, in the internal mammary vessels, and some *behind* in the posterior mediastinal lymphatics.

GLANDS.—The **deep lymphatic glands of the abdomen** are the lumbar glands: they are numerous, and seated around the common iliac vessels, the aorta, and vena cava.

The deep lymphatic glands of the pelvis are the external iliac, internal iliac, and sacral.

The **external iliac** are placed around the external iliac vessels, being in continuation, by one extremity, with the femoral lymphatics; by the other with the lumbar glands.

The **internal iliac** glands are situated in the course of the internal iliac vessels, and the *sacral* glands rest on the concave surface of the sacrum.

VESSELS.—The **deep lymphatic vessels** are continued upwards from the thigh beneath Poupart's ligament, and along the external iliac vessels to the lumbar glands, receiving in their course the epigastric, circumflex iliac, and ilio-lumbar lymphatic vessels. Those from the parietes of the pelvis, and from the gluteal, ischiatic, and obturator vessels, follow the course of the internal iliac veins, and unite with the lumbar lymphatics. The lumbar lymphatic vessels, after receiving all the lymphatics from the lower extremities, pelvis, and loins, terminate by several large trunks in the receptaculum chyli.

LYMPHATICS OF THE VISCERA.

LUNGS.—The **lymphatic vessels of the lungs**, of large size, are distributed over every part of the surface, and through the texture of those organs. They are divisible into a superficial set which lies immediately beneath the pleura, and a deep set which accompanies the ramifications of the bronchial tubes, and pulmonary arteries; they converge to the *bronchial glands*, ten or twelve in number, situated around the bifurcation of the trachea and roots of the lungs. Some of these glands, of small size, may be traced in connection with the bronchial tubes into the substance of the lungs. The efferent vessels from the bronchial glands unite with the tracheal and œsophageal glands, and terminate on the left side in the thoracic duct at the root of the neck, and on the right in the ductus lymphaticus dexter. The bronchial glands in the adult present a variable tint of brown, and in old age a deep black colour. In infancy they have none of this pigment, and are not to be distinguished from lymphatic glands in other situations.

HEART.—The **lymphatic vessels of the heart** originate in the subserous areolar tissue of the surface, and in the deeper tissues of that organ, and follow the course of the coronary vessels, principally,

along the right border of the heart to the glands situated around the arch of the aorta, and to the bronchial glands, whence they proceed to the root of the neck, and terminate in the thoracic duct. The *cardiac glands* are three or four in number.

The **pericardiac** and **thymic** lymphatic vessels proceed to join the anterior mediastinal and bronchial glands.

Liver.—The **lymphatic vessels of the liver** are divisible into deep and superficial. The former take their course through the portal canals, and through the right border of the lesser omentum, to the lymphatic glands situated in the course of the hepatic artery and along the lesser curve of the stomach. The *superficial* lymphatics are situated in the areolar structure of the proper capsule, over the whole surface of the liver, The lymphatics of the convex surface are divided into two sets :—1. Those which pass from before backwards ; 2. Those which advance from behind forwards. The former unite to form trunks, which enter between the folds of the lateral ligaments at the right and left extremities of the organ, and of the coronary ligament in the middle. Some of these pierce the diaphragm and join the posterior mediastinal glands ; others converge to the lymphatic glands situated around the inferior cava. Those which pass from behind forwards consist of two groups ; one ascends between the folds of the broad ligament, and perforates the diaphragm, to join the anterior mediastinal glands finally emptying their contents into the ductus lymphaticus dexter; the other curves around the anterior margin of the liver to its concave surface, and from thence to the glands in the right border of the lesser omentum. The lymphatic vessels of the concave surface are variously distributed, according to their position ; those from the right lobe terminate in the lumbar glands ; those from the gall-bladder, which are large, and form a remarkable plexus, enter the glands in the right border of the lesser omentum ; and those from the left lobe converge to the lymphatic glands situated along the lesser curve of the stomach.

Spleen and Pancreas.—The **lymphatic glands of the spleen** are situated around its hilum, and those of the *pancreas* in the course of the splenic vein. The *lymphatic vessels* of these organs consist of two sets, superficial and deep ; they pass through their respective glands, and join the aortic glands previously to terminating in the thoracic duct.

Stomach.—The **lymphatic glands of the stomach**, of small size, are situated along the lesser and greater curve of that organ. The *lymphatic vessels*, as in other viscera, are superficial and deep, the former originating in the subserous, the latter in the submucous tissue ; they pass from the stomach in four different directions : some ascend to the glands situated along the lesser curve ; others descend to those occupying the greater curve ; a third set pass outwards to the splenic glands, and a fourth to the glands situated near the pylorus and to the aortic glands.

Intestines.—The **lymphatic glands of the small intestine** are

situated between the layers of the mesentery, in the meshes formed by the superior mesenteric artery, and are thence named *mesenteric glands.* These glands are most numerous and largest, superiorly, near the duodenum; and, inferiorly, near the termination of the ileum.

The **lymphatic vessels** of the small intestines are of two kinds: those of the structure of the intestine, which run upon its surface previously to entering the mesenteric glands; and those which commence in the villi, in the substance of the mucous membrane, and are named lacteals.

The **lacteals,** according to Henle, commence in the centre of each villus as a cæcal tubulus, which opens into a fine network, situated in the submucous tissue. From this network the lacteal vessels proceed to the mesenteric glands, and from thence to the thoracic duct, in which they terminate.

The **lymphatic glands of the large intestines** are situated along the attached margin of the intestine, in the meshes formed by the colic and hæmorrhoidal arteries previously to their distribution. The *lymphatic vessels* take their course in two different directions; those of the cæcum, ascending colon, and transverse colon, after traversing their proper glands, proceed to the mesenteric glands, and those of the descending colon and rectum to the lumbar glands.

Kidney.—The **lymphatic vessels of the kidney** follow the direction of the blood-vessels to the lumbar glands situated around the aorta and inferior vena cava; those of the supra-renal capsules, which are very large and numerous, terminate in the renal lymphatics.

Pelvis.—The **lymphatic vessels of the viscera of the pelvis** terminate in the sacral and lumbar glands.

The **lymphatic vessels of the testicle** take the course of the spermatic cord, in which they are of large size; they terminate in the lumbar glands.

THORACIC DUCT.

The thoracic duct, the great trunk of the lymphatic and chylous system, commences in the abdomen by a considerable and somewhat triangular dilatation, the **receptaculum chyli,** which is situated on the front of the body of the second lumbar vertebra, behind and between the aorta and inferior vena cava, and close to the tendon of the right crus of the diaphragm. From the upper part of the receptaculum chyli the thoracic duct ascends through the aortic opening of the diaphragm, and along the front of the vertebral column, lying between the thoracic aorta and vena azygos and upon the right intercostal arteries, to the fourth dorsal vertebra. It then inclines to the left side, passes behind the arch of the aorta, and ascends by the side of the œsophagus, and behind the perpendicular portion of the left subclavian artery to the root of the neck opposite the seventh cervical vertebra, where it makes a sudden curve for-

wards and downwards in front of the scalenus anticus muscle, and terminates at the point of junction of the left subclavian with the left internal jugular vein.

The thoracic duct is about eighteen or twenty inches in length, and near its origin as large as a goose quill; as it ascends, it diminishes in size, and near its termination again becomes dilated.

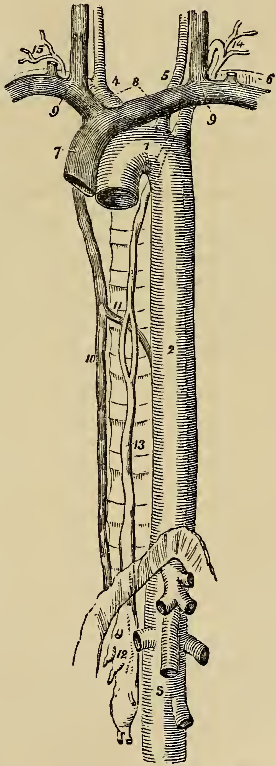


FIG. 268.—The course and termination of the thoracic duct. 1. Arch of the aorta. 2. Thoracic aorta. 3. Abdominal aorta, showing its principal branches divided near their origin. 4. Arteria innominata, dividing into right carotid and right subclavian. 5. Left carotid. 6. Left subclavian. 7. Superior cava, formed by the union of (8) the two venæ innominatæ; and these by the junction (9) of the internal jugular and subclavian vein at each side. 10. Greater vena azygos. 11. Termination of the lesser in the greater vena azygos. 12. Receptaculum chyli; several lymphatic trunks are seen opening into it. 13. Thoracic duct, dividing opposite the middle of the dorsal vertebræ into two branches which reunite; the course of the duct behind the arch of the aorta and left subclavian artery is shown by a dotted line. 14. The duct making its turn at the root of the neck and receiving several lymphatic trunks previously to terminating in the posterior aspect of the junction of the internal jugular and subclavian vein. 15. Termination of the trunk of the ductus lymphaticus dexter.

At the middle of the thorax it frequently divides into two branches of equal size, which reunite after a short course; and sometimes it gives off several branches, which assume a plexiform arrangement in this situation. Occasionally the thoracic duct bifurcates at the upper part of the thorax into two branches, one of which opens into the point of junction between the right subclavian and jugular vein, while the other proceeds to the normal termination of the

duct on the left side. In rare instances the duct has been found to terminate in the vena azygos, which is its normal destination in some mammalia.

The thoracic duct presents fewer valves in its course than lymphatic vessels generally; at its termination it is provided with a pair of semilunar valves, to prevent the admission of venous blood.

Branches.—The thoracic duct receives at its commencement four or five large lymphatic trunks, which unite to form the receptaculum chyli; it next receives the trunks of the lacteal vessels. Within the thorax it is joined by the lymphatic vessels from the left half of the thoracic wall, those of the sternal and intercostal glands, those of the left lung, left side of the heart, trachea, and œsophagus, and at its curve forwards in the neck it is joined by lymphatic trunks from the left side of the head and neck, and left upper extremity.

The **ductus lymphaticus dexter** is a short trunk which receives the lymphatic vessels from the right side of the head and neck, right upper extremity, right side of the thorax, right lung, and one or two branches from the upper convex surface of the liver. It terminates at the junction of the right subclavian with the right internal jugular vein, at the point where these veins unite to form the right vena innominata; and is provided at its termination with a pair of semilunar valves, which prevent the entrance of blood from the veins.

PART VI.

NEUROLOGY.

The nervous system consists of large masses of nerve matter forming the cerebro-spinal axis, of lesser centres called ganglia, the largest and most important of which are connected with the nerves distributed to the viscera, of the peripheral nerves, and, lastly, of certain modifications of the latter constituting the organs of sense.

THE CEREBRO-SPINAL AXIS.

The mass of nerve matter forming the cerebro-spinal axis is contained in the cavity of the cranium and vertebral canal; it is divided into two parts—the *encephalon* or *brain* and the *spinal cord;* each lateral half of these centres corresponds accurately with the other half, the two parts being joined together by connecting bands of nerve tissue called *commissures.* The brain, contained in the cranium, and the spinal cord occupying the vertebral canal, are protected by the osseous walls of those cavities, and are also surrounded by *meninges* or membranes which support them and convey to their substance the vessels necessary for their nutrition.

The great centres of the cerebro-spinal nervous system are most easily understood by taking them up in the following order: spinal cord, medulla oblongata, cerebrum, and cerebellum; thus beginning with the more simple or elementary and proceeding to the more complex.

SPINAL CORD.

The spinal cord of the adult, from fifteen to eighteen inches in length, extends from the foramen magnum to opposite the lower border of the body of the first lumbar vertebra, where it terminates in a conical point (conus medullaris), retained in position by the filum terminale; in the child, at birth, the cone reaches the middle of the third lumbar vertebra, and in the embryo is prolonged as far as the lower part of the sacral canal. The cord presents a difference

of diameter in different parts of its extent, and has two enlargements. The uppermost of these corresponds with the origin of the nerves destined to the upper extremities (cervical); and the lower enlargement (lumbar) is situated near its termination, and corresponds with the attachment of the nerves which are intended for the supply of the lower limbs. The cervical enlargement is flattened from before backwards, and extends from the third cervical vertebra to the first dorsal; the lumbar enlargement is flattened from side to side, and is smaller than the brachial. The spinal cord gives off near its termination that assemblage of nerves which has received the name of *cauda equina;* the cauda equina is formed by the roots of the lumbar and sacral nerves elongated by the growth of the spine, the ganglia of the posterior roots being held in connection with the intervertebral foramina through which the nerves pass.

The spinal cord is held in its place by its connection above with the medulla oblongata at the foramen magnum, and below by the attachment of the filum terminale to the base of the coccyx; laterally it is secured by a membrane, the *ligamentum dentatum*, which passes from its lateral aspect to join the dura mater, and by the spinal nerves which are fixed to the membranes and bones at the intervertebral foramina. It is much larger than the canal in which it lies, being separated from the osseous walls by the membranes, dura mater, arachnoid, and pia mater, by venous plexuses and areolar tissue.

In form, the spinal cord is a flattened cylinder, and presents on its anterior surface a fissure, which extends into the cord to the depth of one-third its diameter, and is occupied by a fold of pia mater. This is the **anterior median fissure.** If the sides of this fissure be gently separated, they will be seen to be connected at the bottom by a layer of white substance, the **anterior white commissure.** In the middle line behind and corresponding with the anterior fissure is the **posterior median fissure,** which contains a few blood-vessels and a little connective tissue. It extends more deeply into the cord than the anterior fissure, and reaches the grey substance of the interior forming the **posterior grey commissure.** These two fissures divide the spinal cord into two lateral portions, which are connected to each other by the white commissure which forms the bottom of the anterior fissure, and by a mass of grey matter situated behind it. On each side of the posterior median fissure is a slight line which marks the limits of the posterior median columns. These columns are most apparent at the upper part of the cord, and become continuous in the medulla oblongata, with the posterior pyramids, or funiculi graciles.

Two other lines are observed on the medulla, the anterior and posterior lateral sulci, corresponding with the attachment of the anterior and posterior roots of the spinal nerves. The *anterior lateral sulcus* is a mere trace, marked only by the attachment of the filaments of the anterior roots; the *posterior lateral sulcus* is somewhat more evident.

These fissures and sulci indicate a division of the spinal cord into three pairs of columns, namely, anterior, lateral, and posterior; or, as they are frequently described, into antero-lateral and posterior.

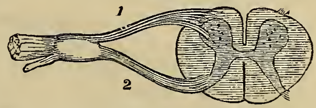


FIG. 269. — Transverse section of the spinal cord, showing the roots of the spinal nerves. 1. Anterior root. 2. Posterior root, with its ganglion.

If a transverse section of the spinal cord be made, its internal structure may be seen and examined. It will then appear to be composed of two hollow cylinders of white substance placed side by side, and connected by a narrow *white commissure.* Each cylinder is filled with grey substance, which is connected by a commissure of the same matter (*grey commissure*). The form of the grey substance, as observed in the section, is that of two irregularly curved or crescentic lines joined by a transverse band. The extremities of the curved lines corresponding with the sulci of origin of the anterior and posterior roots of the nerves are termed cornua; the **anterior cornu** is short and thick; the **posterior cornu,** long and slender, reaches nearly to the surface of the posterior lateral sulcus. The back part of the posterior horn is enlarged and is called the *caput cornu posterioris*, the constricted portion behind this being distinguished as the *cervix cornu.* At the tip of the caput cornu the grey matter has a semi-transparent appearance, and was called by Rolando the *substantia cinerea gelatinosa.*

Filum Terminale.—This is a fine thread which passes down from the conical end of the cord to be attached to the lower part of the sacral canal or base of the coccyx; in its course downwards it lies in the middle of the nerves forming the cauda equina. For about half its length it contains nervous elements continued into it from the cord, contained in a sheath of pia mater, the latter forming the chief portion of the thread and being the means by which the cord is held in place. At the lower part of the vertebral canal it is attached to the dura mater and wall of the canal.

Central Canal.—In the centre of the grey matter of the cord there is a minute canal lined by cylindrical ciliated epithelium, which extends upwards into the fourth ventricle, and down into the filum terminale. It is always present in the young subject, but often in the spinal cord of the adult it becomes indistinct from being filled up with cells and granular matter.

Structure of the Spinal Cord.—The pia mater closely invests the spinal cord, and sends processes into the anterior and posterior median fissures, which convey blood-vessels for the interior of the cord. Beneath it, and not usually distinctly separable from its structure, is a covering of connective tissue from which processes pass into the white matter of the cord so as to form partial septa between its several parts; with the fibres of this tissue numerous gelatinous cells are observed, many sending prolongations along the fibrous septa, which in the interior of the cord become continuous

with fine cells forming a delicate matrix for the support of the nervous elements. This matrix has been termed by Virchow *neuroglia;* the cells of it are probably modified connective-tissue corpuscles; they are distinguished by their minute granule-like nuclei. The outer or white part of the cord consists chiefly of medullated nerve fibres arranged longitudinally, the larger ones measuring $\frac{1}{150}$ inch in diameter, the smaller $\frac{1}{1500}$; transverse fibres forming the nerve roots also cross the white matter at short intervals. The inner or grey part is composed of nerve cells and grey or non-medullated nerve fibres. The cells are of two kinds, large branched cells containing nuclei and pigment, and small cells for the most part round, some of them being so fine as to resemble free nuclei. The large cells are collected into groups, there being in the anterior cornu usually two of these, one at its anterior, the other at its outer part; in the posterior horn the most important group is a large one placed near the posterior commissure, and called by Clarke the **posterior vesicular column** (fig. 270, *c*). A group of large cells is also found near the outer margin of the grey matter, about midway between the anterior and posterior horns; it is named **tractus intermedio-lateralis** (fig. 270, *d*). The small cells are found scattered throughout the whole of the grey matter, but are aggregated in the substantia gelatinosa of the posterior horn, and there lie in a fine fibrous basis. The *anterior commissure* is formed of medullated fibres, some of which pass into the anterior column of white matter, and others into the anterior horn of grey matter. The *posterior commissure* consists of grey nerve fibres which connect the grey columns of the two sides and pass into the posterior horns.

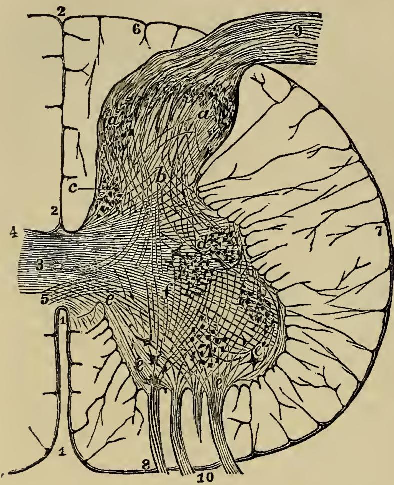


FIG. 270.—Transverse section of half the spinal cord. 1, 1. Anterior median fissure. 2, 2. Posterior median fissure. 3. Central canal. 4. Posterior commissure. 5. Anterior commissure. 6. Posterior column. 7. Lateral column. 8. Anterior column. 9. Posterior root. 10. Anterior root. *a, a.* Caput cornu posterioris. *b.* Cervix cornu. *c.* Posterior vesicular columns. *d.* Intermedio-lateral tract. *e, e.* Fibres of the anterior roots joining the anterior horn. *f.* Fibres running from anterior to posterior cornu.

Origin of the Nerves.—The spinal nerves arise by two roots, the distinctive characters of which, outside the spinal cord, will be described hereafter; their connection with the nerve centre is here noted.

The anterior roots pass through the substance of the white matter into the anterior horns, where they separate and can be traced into the antero-lateral column of the same side, while some seem to be connected with the anterior or white commissure.

The posterior roots have very wide connections. Some pass into the deep or innermost part of the lateral division of the antero-lateral column. Some after diverging in the posterior horns are continued upwards and downwards, while others pass across the grey column into the opposite half of the cord.

From the foregoing description it will appear that the spinal cord can be divided anatomically into three great columns or strands on each side. 1. The posterior column, which is defined by being enclosed within the posterior horns of the grey matter; with this the roots of the nerves are not connected, except perhaps by some few fibres. 2. The antero-lateral column, consisting of the whole remaining white matter of the cord. 3. The central or grey column with its horns, encased by the two former. The spinal cord is clearly the channel of connection between the brain and the roots of the spinal nerves, but the anatomical connection of the nerve fibres it is impossible to demonstrate. That some of the fibres are continuous throughout the whole length of the spinal cord is extremely probable, but that many more are oblique is proved by the view of sections at almost any point. The following interpretation of the connection between the roots of the nerves and the columns of the cord, is founded on the well-known experiments of Dr. Brown-Séquard.

The posterior columns are not in any way concerned in the transmission of sensory or motor impressions.

The anterior and the greater portion of the lateral part of the antero-lateral column serves to transmit motor impulses to the anterior roots of the same side.

The grey column, and probably that part of the antero-lateral column which lies deep in the hollow of the crescent between the

FIG. 271.—Transverse section of the spinal cord. 1. Posterior column. 2. Antero-lateral column. 3. Deep part of the same enclosed between the anterior and posterior horns of the grey column. 4. Central or grey column.

anterior and posterior cornua is the channel for sensory impulses to travel from the posterior roots upwards, but these sensory impulses pass at once across into the opposite half of the cord.*

The grey matter, besides being the channel for sensation, is also the principal centre of reflex action.

* The anatomical description of the columns of the cord differs slightly from that which Dr. Brown-Séquard has deduced from his experiments, inasmuch as there is included in the sensory column the deep part of the antero-lateral column. It seems to the Editors that experiments which propose to divide the *whole* of the white matter leaving the grey entire, cannot be done with the precision necessary for physiological deduction. In fact, in the experiments recorded, when the knife was made to pass so close to the central canal as to ensure the division of *all* the white matter, sensation was impaired. The Editors believe that it was so because the deep part of the antero-lateral column was included in the section.

THE ENCEPHALON.

The encephalon, or that part of the cerebro-spinal centre contained within the cranium, consists of the medulla oblongata and mesocephalon, cerebrum, and cerebellum. The whole mass weighs on an average about fifty ounces for the male, and forty-four for the female.

MEDULLA OBLONGATA.

The medulla oblongata is the upper enlarged portion of the spinal cord. It is oblique in its position, its upper surface looking upwards and backwards, and its lower downwards and forwards; the former constitutes the floor of the fourth ventricle, the latter lies on the basilar portion of the occipital bone. It is somewhat conical in shape, and a little more than an inch in length, extending from the pons Varolii to a point corresponding with the upper border of the atlas. On the middle line, in front and behind, the medulla oblongata is marked by two vertical fissures, the anterior and posterior median fissures, which divide it superficially into two symmetrical lateral cords or columns, and are continuous with the anterior and posterior fissures of the spinal cord; whilst each lateral column is subdivided by shallow grooves into four smaller divisions, namely, the anterior pyramids, olivary bodies, restiform bodies, and posterior pyramids.

The **anterior pyramids** are two narrow convex cords, tapering slightly from above downwards, and situated one on either side of the anterior median fissure. At about an inch below the pons they communicate across the fissure by a decussation of their fibres (the *decussation of the pyramids*), and at their point of entrance into the pons are constricted into round cords. The fissure is somewhat enlarged by this constriction, and the enlarged space has received the name of foramen cæcum (Vicq d'Azyr) of the medulla oblongata.

The **decussation of the pyramids** does not involve the whole of the fibres of those bodies, but chiefly affects the strands placed most internally; the greater number of fibres are derived from the deep part of the lateral column of the cord, they come to the surface by displacing those of the anterior column outwards, and cross to the anterior pyramid of the opposite side; they are accompanied by some fibres derived from the posterior part of the grey matter of the cord. The outer portion of each pyramid does not decussate; it consists of fibres derived from the anterior column of the same side of the cord.

The **olivary bodies** (named from some resemblance in shape to an olive) are two oblong, oval-shaped convex bodies, of about the same breadth as the anterior pyramids, about half an inch in length, and somewhat larger above than below. The olivary body is situated immediately external to the anterior pyramid, from which, and from the restiform body, it is separated by a groove. In this groove some longitudinal fibres are seen which pass on each side of

the olivary body; they are continuous with the fibres of the anterior column of the cord. Being joined by fibres originating in the olivary nucleus they form the *olivary fasciculus*; traced through the substance of the pons Varolii they will be found to terminate in the corpora quadrigemina and cerebral hemispheres. Besides these there are other fibres which curve round the lower part of the corpus olivare, these are the *arciform fibres*, and seem to be fibres of the anterior pyramids proceeding to join those of the restiform column. When examined by section the olivary body is found to be a ganglion deeply embedded in the medulla oblongata, and meeting its fellow at the middle line behind the anterior pyramid. The ganglion of the olivary body (corpus dentatum, olivary nucleus), like that of the cerebellum, is a yellowish-grey dentated capsule, open behind, and containing grey substance and transverse white fibres. The nervous filaments which spring from the groove on the anterior border of the olive are those of the hypoglossal nerve; and those on its posterior border are the glosso-pharyngeal, pneumogastric, and accessory part of the spinal accessory.

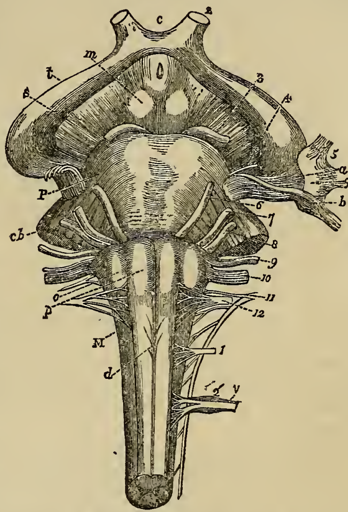


FIG. 272.—Front view of the upper part of the cranio-spinal axis, with the origins of the nerves. M. Medulla oblongata. *p.* Anterior pyramids. *d.* Their decussation. *o.* Olivary bodies. P. Pons Varolii. *cb.* Crus cerebelli. *s.* Crus cerebri. *m.* Corpora mammillaria. *t.* Tractus opticus. *c.* Chiasma. 2. Optic nerve. 3. Motor oculi. 4. Patheticus. 5. Fifth pair. *a.* Its larger root. *b.* Its smaller root. *g.* Gasserian ganglion. 6. Abducens. 7. Facial. 8. Auditory. 9. Glosso-pharyngeal. 10. Vagus. 11. Spinal accessory. 12. Hypoglossal. 1′. First spinal nerve. 2′. Second spinal nerve. *v.* Its ganglion.

The **restiform bodies** (*restis*, a rope) comprehend the greater part of the posterior half of each lateral column of the medulla oblongata. They are separated from the olivary bodies by the grooves already spoken of; posteriorly they are divided from each other by the posterior median fissure and fourth ventricle, and superiorly they diverge and curve backwards to enter the cerebellum, and constitute its inferior peduncles. The restiform body is crossed near its entrance into the cerebellum by the auditory nerve, the choroid plexus of the fourth ventricle, and the pneumogastric lobule.

Along the posterior border of each restiform body, and marked off from that body by a groove, is a narrow white cord, separated from its fellow by the posterior fissure. These narrow cords are

termed the **posterior pyramids** (fasciculi graciles). They are continuous with the posterior median columns of the spinal cord. Each fasciculus forms an enlargement (processus clavatus) at its upper end, and is then lost in the fasciculi teretes of the floor of the fourth ventricle; the fibres accompany those columns to the cerebrum. The posterior pyramids are the lateral boundaries of the nib of the calamus scriptorius.

The remaining portions of the medulla oblongata visible from the exterior, are the two slightly convex columns which enter into the formation of the floor of the fourth ventricle. These columns are the *fasciculi teretes* (innominata). The fasciculi teretes are coated with grey nerve matter, and are crossed by three or four white delicate bands called the *lineæ transversæ*, which are the fibres of origin of the auditory nerve.

The medulla oblongata is the continuation upwards of the columns of the spinal cord, besides containing a collection of ganglia or special centres of the most important cranial nerves. The mode in which the various component parts of the spinal cord pass up into the medulla and through it to the mesocephalon is rather complex and has given rise to unnecessary complication in description; the following is a simple account of the probable arrangement of its fibres.

The anterior pyramids, which are shaped like a long wedge (see fig. 273), are the direct continuation upwards of the anterior or motor part of the antero-lateral column of the cord—the decussation permitting most of the fibres of one side of the cord to pass into the opposite side of the medulla.

The greater part of the remaining fibres of the antero-lateral column, together with the posterior column of the cord, diverge from it at the calamus scriptorius, and are directed outwards and backwards towards the cerebellum, forming the *restiform* column.

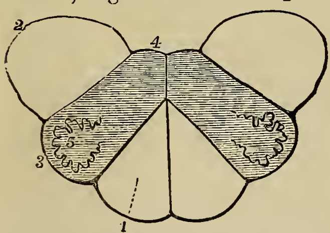


FIG. 273.—Diagrammatic section of the medulla oblongata. 1. Anterior pyramidal or motor column. 2. Restiform column. 3. Olivary body. 4. Fasciculi teretes in fourth ventricle. 5. Corpus dentatum in olivary body. The olivary or sensory column is shaded.

The posterior pyramids or processus graciles, after running along the inner edge of the posterior column, sink down and become continued into the *fasciculi teretes* of the fourth ventricle.

The remaining portions of the medulla are the olivary bodies and fasciculi teretes of the fourth ventricle. These two seem to be the direct continuation upwards of the central or grey column of the cord, together with the deeper part of the antero-lateral column of the cord, formerly alluded to as lying in the hollow of the crescent between the anterior and posterior horns of the grey column. In the spinal cord this deep central

part is concealed, by being overlaid by the posterior and superficial layer of the antero-lateral columns, but in the medulla it comes into view, behind in consequence of the separation and divergence of the restiform tract, and in front by the projection of the olivary body, which here crops out and separates the anterior pyramidal from the restiform continuations of the antero-lateral column. In this view the whole thickness between the olivary body and fasciculi teretes is the olivary column, which thus consists of white fibres derived from the before-mentioned deep part of the antero-lateral column and other superadded white fibres, together with the grey or vesicular column of the cord ; and in addition the nucleus of the olivary body and the special collections of grey matter which form the centres of origin of the special nerves of the medulla. Through this olivary column sensation is transmitted upwards from the central parts of the spinal cord.

THE MESOCEPHALON.

The mesocephalon, considered as a separate division of the encephalon, may be defined as that portion corresponding internally to the prominence of the *pons Varolii* on the surface. It is limited below by the medulla oblongata, above by the crura cerebri, on each side by the hemispheres of the cerebellum, in front by the pons, and behind by the corpora quadrigemina. Its complex system of fibres serves to connect the medulla oblongata with the cerebrum, the cerebellum with the cerebrum, and the two lateral halves of the cerebellum with each other.

The **pons Varolii** is a convex arch of white matter, situated above the medulla, and extending from side to side, slightly constricted where it enters the cerebellum at each side, to form part of the crus cerebelli. The transverse direction of its fibres point it out as the *intercerebellar commissure.* In the middle it is grooved for the basilar artery. On viewing a section of the pons, it will be seen that it is not wholly or chiefly composed of transverse fibres, but that it is traversed by strands of longitudinal white matter, and contains deposits of grey nerve matter. The longitudinal strands are not collected into one bundle, but alternate with transverse bands of the true fibres of the pons, so that it is only the superficial transverse bands of the pons which conceal the more complex arrangement of nerve matter within.

To understand the anatomy of this underlying mass, it will be convenient to study what is seen on a longitudinal section of the brain, made a little to one side of the mesial line, and in explaining this, the description refers to parts above the mesocephalon, as well as to the parts of the medulla oblongata. In such a section (see fig. 274) the three strands of the medulla, the anterior pyramidal, the olivary, and the restiform, can be seen. The restiform can be traced turning backwards into the cerebellum. The anterior pyramidal can be traced through below the surface of the pons, forward into a bar of white matter, which emerges at the upper edge of the pons,

and is called the crus cerebri. It is easy to recognise this track as the continuation upwards of the motor column, and if the section be followed still farther, it will be found that this expands into a pear-shaped body, consisting of streaks of white, with dark-grey or brown nerve matter intervening. This is the *corpus striatum*, the anterior or motor ganglion of the brain.

The olivary or central column can in like manner be traced through a deeper layer of the pons, and will also be found to emerge above it as the posterior part of the *crus cerebri*, being separated from the former part by a collection of dark-grey nerve matter called the *locus niger*. Traced farther on, this column is

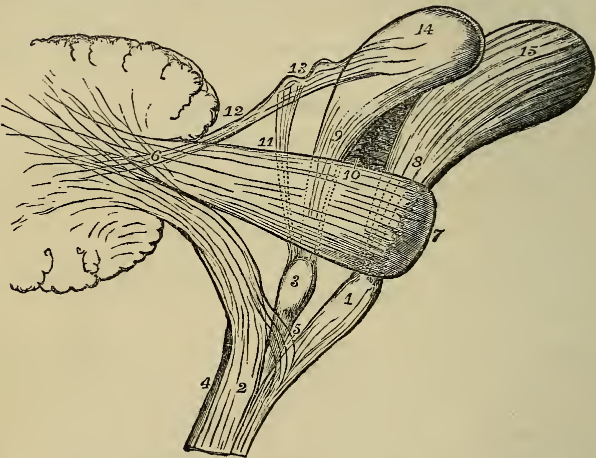


FIG. 274.—Diagram of a section of the medulla oblongata, mesocephalon, crus cerebri, and cerebral ganglia. 1. Anterior pyramid. 2. Restiform column. 3. Olivary body and column. 4. Posterior pyramid. 5. Arciform fibres. 6. Crus cerebelli. 7. Pons Varolii. 8. Motor column in anterior part of crus cerebri. 9. Sensory column in posterior part of crus. 10. Locus niger. 11. The olivary fasciculus. 12. Processus e cerebello ad testes. 13. Corpora quadrigemina. 14. Thalamus opticus. 15. Corpus striatum.

found to expand into a round bulb of a grey or coffee colour, situated immediately behind, and resting against the corpus striatum, and called the *thalamus opticus*. The column is the continuation upwards of the sensory tract, and the bulbous expansion is the sensory ganglion.

At the back part of the section will be seen a band, which proceeds from the centre of the cerebellum onwards towards the thalamus opticus, and before reaching it, has two little pea-like elevations on it, the interior of which contains grey matter; the band is the *processus e cerebello ad testes*, or cerebro-cerebellar commissure, and the pea-like elevations are the *corpora quadrigemina*,

or *nates* and *testes*. The band alluded to forms part of the crus cerebelli. Between the two *processus cerebelli* is a space called the fourth ventricle, and this is covered in by a thin veil of whitish-grey matter, stretched between the two bands, and called the *valve of Vieussens.*

Besides the strands already mentioned, another small collection of fibres is described as leaving the anterior pyramidal tract close to the olivary body, and ascending deeply through the pons to be connected with the corpora quadrigemina. Whether these fibres really belong to the anterior pyramid, or to the column connected with the olivary body, is doubtful, but they are usually termed the *olivary fasciculus.* It seems better, however, to regard them as a mere offshoot of the primary column, and to retain the name *olivary column* for the part already described as ascending to the thalamus opticus from the central part of the spinal cord.

FIG. 275.—Diagrammatic view of the connection between the columns of the medulla and the convolutions of the brain. 1. Anterior part of the crus cerebri extending to the corpus striatum and its fibres radiating to the convolution. 2. The posterior part of the crus cerebri expanding into the thalamus opticus, from which fibres radiate to the convolutions. 3. The convolutions.

The fibres from these columns do not, however, terminate in the corpus striatum and thalamus opticus, but are continued onwards into the white substance of the brain, which lies beyond these ganglia, and is connected with them in front, outside, and below them. By this, the white fibrous substance of the brain, the columns of the medulla oblongata, and the collections of vesicular nerve matter which form the special centres in it, and the mesocephalon, are connected with the convolutions which exist on its surface. In this view the brain is just an expansion of the columns of the cord, with the addition of nerve centres connected with the special nerves of the head, and others which seem to be related to the operations of the mind.

The two sides of the brain are connected with each other by commissures, the principal of which is the corpus callosum, the descriptive anatomy of which will be included in the account of the dissection of the brain, but at present it may be stated that it consists of a thick band of white nerve matter, the antero-posterior measurement of which is about one-half of the length of the ence-

phalon. The fibres of which it is composed are parallel and transverse, and extend from the convolutions of one hemisphere to those of the other.

The white matter of the cerebrum therefore may be considered as composed of fibres radiating out from the corpus striatum and thalamus opticus, and of transverse fibres belonging to the corpus callosum; but it must be remembered that no *direct* continuation of fibres can be traced between the medulla and the convolutions, and certainly the white matter of the brain contains an amount of fibres out of all proportion to the small quantity in the columns of the cord. Besides the three sets of fibre above alluded to, there have to be added certain longitudinal fibres forming what may be considered antero-posterior commissures and the small transverse commissures seen in the third ventricle.

Course of the Fibres in the Medulla.

The foregoing general description of the brain and its connections will have prepared the student for the careful study of their several parts; but it will be necessary before entering on this that he should receive a more exact account than has been given above of the course of the nerve fibres from the spinal cord through the medulla oblongata and crura cerebri to the brain.

The strands or column of the spinal cord have been described above (p. 479) as three in number on each side, namely, the *anterior*, *lateral*, and *posterior*, but a portion of the latter is marked off from the rest by an imperfect septum, and forms the *posterior median column*; it is most distinct in the cervical and upper dorsal region.

The **anterior column** when it reaches the lower part of the anterior pyramids gets displaced outwards by the fibres which cross from the lateral column of the opposite side in the decussation of the pyramids; it then divides into three sets of fibres which may be called external, middle, and internal. The *external* set constitute the arciform fibres described above as passing below the olivary body to reach the restiform column; they are continued along with it to the cerebellum. The *internal* fibres ascend in the outer part of the anterior pyramid, and pass through the pons along with those derived from the lateral column of the opposite side of the cord; in the crus cerebri they form the upper portion or *crusta* of that band, and may be traced into the corpus striatum or motor ganglion of the cerebrum. The *middle* fibres form two strands which pass on each side of the olivary body, and, uniting at its upper border, are joined by a few fibres derived from the olivary nucleus, so as to form what is known as the *olivary fasciculus*. This runs along the outer side of the crus cerebri, where it is called the *fillet*, and divides into two portions, one of which ends in the corpora quadrigemina, and the other passes with the upper part of the crus to the cerebrum.

The **lateral column** at the base of the olivary body divides into three strands; the *external* of these passes to the restiform body, and with it is continued to the cerebellum. The *middle* strand passes upwards on the same side of the medulla to the upper surface of the olive as the fasciculus teres which forms the floor of the fourth ventricle; higher up it constitutes the upper portion of the crus cerebri, and is called the *tegmentum;* traced upwards to the cerebrum it is found to terminate in the thalamus opticus. The *internal* fibres cross to the anterior column of the opposite side of the medulla oblongata, and are continued with them to the crus cerebri and corpus striatum.

The **posterior column** passes entirely into the restiform body, but some of the fibres of the latter join the posterior pyramid and with it pass upwards to join the fasciculus teres of the same side, and so are continued to the thalamus opticus of the cerebrum.

The **posterior median column** forms the posterior pyramid of the medulla; at about the middle of the fourth ventricle it sinks into the general level of the fasciculus teres, and is continued along with the fibres of that strand to the tegmentum of the crus and thence to the cerebrum.

The connections and course of the fibres of these columns will be better understood by a reference to the plan given on the next page (fig. 276).

CEREBRUM.

The cerebrum presents on its surface a number of slightly convex elevations, the convolutions (gyri), which are separated from each other by sulci of various depth. It is divided superiorly into two hemispheres by the great longitudinal fissure, which lodges the falx cerebri, and marks the original development of the brain by two symmetrical halves.

Each hemisphere admits of division into five lobes—frontal, parietal, occipital, temporo-sphenoidal, and central. The *frontal lobe* rests on the roof of the orbit, and is separated from the temporo-sphenoidal by the fissure of Sylvius. The *temporo-sphenoidal lobe* is received into the middle fossa of the base of the skull, and is separated from the posterior by a slight impression produced by the ridge of the petrous bone. The *occipital lobe* is supported by the tentorium. The *central lobe*, or island of Reil, lies in the fissure of Sylvius, and is covered by the convolutions of the temporo-sphenoidal and parietal lobes.

BASE OF THE BRAIN.

The student should first study the base of the brain; for this purpose the organ should be turned upon its upper surface. The arachnoid membrane, some parts of the pia mater, and the circle of

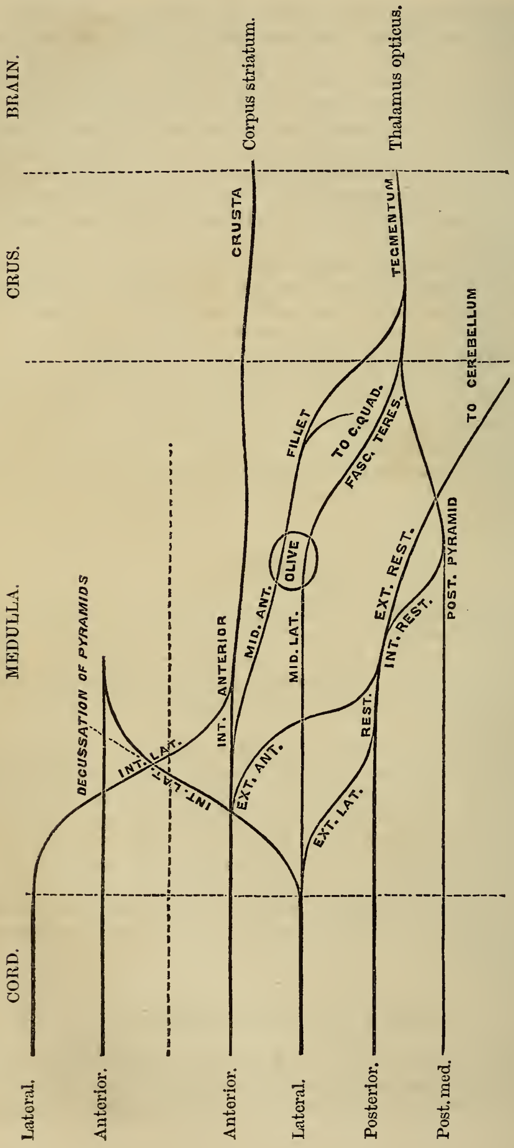


FIG. 276.—Diagram of the course of the fibres through the medulla to the brain.

Willis, must be carefully cleared away, in order to expose all the parts to be examined. These he will find to be as follows :—

Longitudinal fissure,	Commencement of the transverse fissure,
Olfactory nerves,	Optic commissure,
Fissure of Sylvius,	Tuber cinereum,
Substantia perforata ;	Infundibulum ;
Corpora albicantia,	Pons Varolii,
Locus perforatus,	Crura cerebelli,
Crura cerebri ;	Medulla oblongata.

The **longitudinal fissure** is the space separating the two hemispheres ; it is continued downwards to the base of the brain, and divides the two anterior lobes. In this fissure the anterior cerebral arteries ascend towards the corpus callosum ; and if the two lobes be slightly drawn asunder, the anterior border (genu) of the corpus callosum will be seen descending to the base of the brain. Arrived at the base of the brain, the corpus callosum terminates by a concave border, which is prolonged to the commissure of the optic nerves by a thin layer of grey substance, the *lamina cinerea.* The lamina cinerea is the anterior part of the inferior boundary of the third ventricle. On each side of the lamina cinerea the corpus callosum is continued backwards and outwards on each side as a broad white band, these being called the peduncles of the corpus callosum ; they cross the substantia perforata and end at the commencement of the fissure of Sylvius.

On the under surface of each anterior lobe, on either side of the longitudinal fissure, is the *olfactory nerve*, with its bulb.

The **fissure of Sylvius** bounds the frontal lobe posteriorly, and separates it from the temporo-sphenoidal lobe ; it lodges the middle cerebral artery. If this fissure be followed outwards, a small isolated cluster of five or six convolutions (gyri operti) will be observed ; these constitute the **island of Reil.**

The **substantia perforata** (locus perforatus anticus) is a triangular surface coated with grey matter, situated at the inner extremity of the fissure of Sylvius. It is named *perforata* from being pierced by a number of openings for the medullary branches of the middle cerebral artery which enter the brain in this situation to supply the grey substance of the corpus striatum.

Passing backwards on each side beneath the edge of the temporo-sphenoidal lobe, is the commencement of the **great transverse fissure,** which extends beneath the hemisphere of one side to the same point on the opposite side. A probe passed into this fissure between the crus cerebri and temporo-sphenoidal lobe will enter the middle cornu of the lateral ventricle.

The **optic commissure** is situated in the middle line ; it is the point of communication between the two optic nerves.

The **tuber cinereum** is an eminence of grey substance situated immediately behind the optic commissure, and in front of the corpora albicantia. From its centre there projects a small conical body

of grey substance, apparently a prolongation of the tuber cinereum, the **infundibulum.** The infundibulum is hollow, enclosing a short cæcal canal, which communicates with the cavity of the third ventricle; and, below the termination of the canal, the conical process becomes connected with the pituitary gland. The infundibulum and tuber cinereum form part of the floor of the third ventricle.

The **pituitary gland** (hypophysis cerebri) is a small, flattened, reddish-grey body, situated in the sella turcica, and closely retained

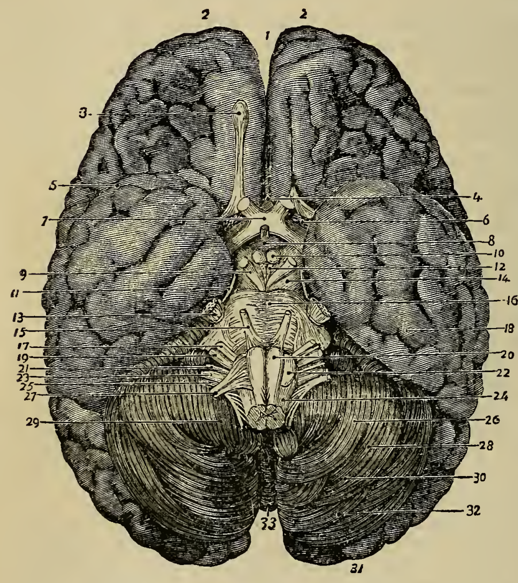


FIG. 277.—The base of the brain. 1. Longitudinal fissure. 2, 2. Anterior lobes of cerebrum. 3. Olfactory bulb. 4. Lamina cinerea. 5. Fissure of Sylvius. 6. Locus perforatus anticus. 7. Optic commissure. 8. Tuber cinereum and infundibulum. 9. Third nerve. 10. Corpus albicantium. 11. Fourth nerve. 12. Locus perforatus posticus. 13. Fifth nerve. 14. Crus cerebri. 15. Sixth nerve. 16. Pons Varolii. 17. Portio dura of seventh. 18. Temporo-sphenoidal lobe of cerebrum. 19. Portio mollis of seventh. 20. Anterior pyramid. 21. Glosso-pharyngeal nerve. 22. Olivary body. 23. Pneumogastric nerve. 24. Lateral tract. 25. Spinal accessory nerve. 26. Digastric lobe. 27. Hypoglossal nerve. 28. Cerebellum. 29. Amygdala. 30. Slender lobe of cerebellum. 31. Occipital lobe of cerebrum. 32. Posterior inferior lobe of cerebellum. 33. Inferior vermiform process of cerebellum.

in that situation by the dura mater and arachnoid. It consists of two lobes, closely pressed together, the anterior lobe being the larger of the two and oblong in shape, the posterior round. Both lobes are connected with the infundibulum, but the latter is so soft in texture as to be generally torn through in the removal of the brain. Indeed, for the purposes of the student, it is better to effect this separation with the knife, and leave the pituitary body *in situ*, to be examined with the base of the cranium.

The **corpora albicantia** (mammillaria, bulbi fornicis) are two white convex bodies, having the shape and size of peas, situated

behind the tuber cinereum, and between the crura cerebri. They are a part of the crura of the fornix, which, after their origin from the thalami optici, descend to the base of the brain, and making a sudden curve upon themselves previously to their ascent to the lateral ventricles, constitute the corpora albicantia. When divided by section, these bodies will be found to be composed of a capsule of white substance, containing grey matter, the grey matter of the two corpora being connected by means of a commissure.

The **locus perforatus posticus** is a layer of whitish-grey substance, connected in front with the corpora albicantia, behind with the pons Varolii, and on each side with the crura cerebri, between which it is situated. It is perforated by several thick tufts of arteries derived from the posterior cerebral which are distributed to the thalami optici and third ventricle, of which latter it assists in forming the floor. It is also called the *pons Tarini.*

The **crura cerebri** (peduncles of the cerebrum) are two thick white cords, which issue from the anterior border of the pons Varolii, and diverge to enter the thalami optici and corpora striata. By their outer side the crura cerebri are continuous with the corpora quadrigemina, and above, they constitute the lower boundary of the aqueduct of Sylvius. Within, they contain grey matter, which has a semilunar shape when the crus is divided transversely, and has been termed the *locus niger.* The third nerve will be observed to arise from the inner side of each crus, and the fourth nerve winds around their outer border from above.

The **pons Varolii** is the broad transverse band of white fibres which arches like a bridge across the upper part of the medulla oblongata; and, contracting on each side into a thick rounded cord, enters the substance of the cerebellum under the name of the crus cerebelli. There is a groove along its middle which lodges the basilar artery. On the lateral aspect of the pons is the thick bundle of filaments belonging to the fifth nerve; lying against its posterior border is the seventh pair of nerves, and between it and the anterior pyramid of the medulla the sixth nerve has its origin.

The **medulla oblongata** is described at p. 480.

Convolutions and Sulci.

The cerebrum is divided into five lobes, which, although intimately connected with each other in its deeper parts, are separated on the surface by well-defined fissures or sulci; they are the **frontal, parietal, occipital, temporo-sphenoidal,** and **central.** The fissures which form the boundaries of these lobes are three in number—the **fissure of Sylvius, fissure of Rolando,** and **parieto-occipital fissure**; these will be first described, after which the different lobes and the convolutions forming them will be studied in detail.

Fissure of Sylvius (fig. 278, *c*, *e*).—This fissure has already been mentioned in connection with the structures at the base of the brain; it consists of two portions, one of which (*c*) passes almost

FIGS. 278, 279.—Lateral view and upper surface of the brain of a bush-woman. C. Central lobe, or island of Reil. F. Frontal lobe. P. Parietal lobe. O. Occipital lobe. T. Temporo-sphenoidal lobe. The lower *c* indicates the anterior division of fissure of Sylvius, the upper *c* the precentral fissure. *d.* Fissure of Rolando. *e.* Sylvian fissure, posterior division. *f.* Parallel fissure. *g.* Inferior temporal fissure. *h.* Parieto-occipital fissure. 1. Lower frontal convolution. 2. Middle frontal convolution. 3. Upper frontal convolution. 4. Ascending frontal convolution. 5. Ascending parietal convolution. 5′. Superior parietal convolution. 4″—5″. Supra-marginal convolution. A. Inferior parietal convolution. 6. Angular convolution. 7. First temporo-sphenoidal convolution. 8. Second temporo-sphenoidal convolution. 9. Third temporo-sphenoidal convolution. 10. First occipital

convolution. 11. Second occipital convolution. 12. Third occipital convolution. α. First or upper external connecting convolution. β. Second external connecting convolution. γ. Third external connecting convolution. δ. Fourth external connecting convolution.

vertically upwards into the frontal lobe; the other (*e*) is directed oblique upwards and backwards, and serves to separate the parietal from the temporo-sphenoidal lobe.

Fissure of Rolando (figs. 278 and 279, *d*).—Placed nearly in the centre of the outer surface of the cerebrum, this fissure is found to commence near the margin of the longitudinal fissure, and to run downwards and forwards, to terminate a little above the posterior portion of the fissure of Sylvius. It divides the frontal from the parietal lobe, and is bounded throughout its entire length by two convolutions, the one in front being the ascending frontal, the one behind the ascending parietal.

The **parieto-occipital fissure** is less distinctly marked than the two just described; it is best seen on the inner surface of the hemisphere (fig. 280, P, O). It commences near the posterior extremity of the corpus callosum, where it is united with the calcarine fissure, and passing upwards and backwards appears on the margin of the hemisphere in the longitudinal fissure; it then runs for a short distance over the external convex surface of the cerebrum, and separates the parietal from the occipital lobe. The extent to which this fissure may be traced in the latter direction varies greatly in different brains; sometimes the fissure is a mere notch at the upper margin of the hemisphere, at other times it extends over a considerable part of its surface.

The **frontal lobe** (figs. 278, 279, and 280, F) forms the anterior part of the brain, its under surface resting on the orbital plate of the frontal bone; it is separated from the parietal lobe by the fissure of Rolando, and from the tempo-sphenoidal lobe by the fissure of Sylvius. On the inner surface of the hemisphere the frontal lobe is not well defined, but is generally described as terminating at the upper limb of the calloso-marginal fissure. The frontal lobe is marked by five fissures, which are the boundaries of the convolutions of which it is composed; two of these called *inferior* and *superior frontal sulci* divide the greater portion of the lobe into three chief convolutions, called respectively the *first*, *second*, and *third*, or *inferior*, *middle*, and *superior frontal gyri* (fig. 278, 1, 2, 3). A fourth fissure called *precentral* runs in front of and nearly parallel with the fissure of Rolando; other fissures called *olfactory* and *orbital* are found on the under surface of the frontal lobe; the first of these lodges the olfactory bulb. The *ascending frontal* convolution (4) bounds the fissure of Rolando anteriorly, and is connected at each extremity of that fissure with the *ascending parietal* convolution.

The **parietal lobe** (figs. 278, 279, and 280, P) is separated in front from the frontal lobe by the fissure of Rolando, below it is bounded by the posterior portion of the fissure of Sylvius, and behind by the parieto-occipital fissure. At the lower and back part it is united with the temporo-sphenoidal and occipital lobes by the

connecting convolutions. It is divided by a deep sulcus, which runs downwards and backwards near its centre and is called the *inter-parietal fissure*, into two chief convolutions, the upper called *superior* and the lower *inferior parietal;* the latter is further divided into two parts, one running along the upper border of the posterior part of the fissure of Sylvius and called *supra-marginal convolution*, the other called *angular gyrus* forming an irregular convolution which connects the temporo-sphenoidal and parietal lobes, and winds round the posterior end of the first temporo-sphenoidal or parallel fissure. The anterior border of the parietal lobe is formed by the ascending parietal convolution, which, as mentioned above, bounds the fissure of Rolando posteriorly.

The **occipitall obe** (O), of small size, forms the posterior termination of the cerebrum; it is imperfectly limited above by the parieto-occipital fissure, but laterally and below is united with the parietal and temporo-sphenoidal lobes by connecting convolutions. It contains three ill-defined convolutions placed horizontally, and named, *first* (10), *second* (11), and *third* (12) occipital gyri.

The **temporo-sphenoidal** or **temporal lobe** (T) fills up the middle fossa of the skull, and is the deepest seated portion of the cerebrum. It is separated from the frontal lobe and anterior part of the parietal lobe by the fissure of Sylvius, but is united to the occipital and parietal lobes posteriorly. It is marked by three fissures, the first of which lies immediately below the posterior part of the fissure of Sylvius, and as it runs in the same direction is named the *parallel fissure*, the other two are called the *middle* and *inferior* temporo-sphenoidal fissures. The chief convolutions are three in number, *first* (7), *second* (8), and *third* (9), temporo-sphenoidal gyri.

The **central lobe** or **island of Reil** (C) is situated in the fissure of Sylvius, being covered by the convolutions of the frontal, parietal, and temporo-sphenoidal lobes, more especially the lower end of ascending parietal and ascending frontal, and the posterior extremity of the inferior frontal convolution, these together constituting the *operculum*. It corresponds in position to the outer surface of the corpus collosum, as may be well seen in a vertical transverse section of the brain (see fig. 287). It is divided into four or five small convolutions which radiate from the centre of its posterior border.

The chief **connecting** or **annectant convolutions** are four in number; the *first* (α), joins the parietal to the upper part of the occipital lobe, the *second* (β), connects the angular gyrus of the parietal with the first convolution of the occipital lobe, and the *third* (γ), and *fourth* (δ), connect the second and third temporal convolutions with the occipital lobe.

The Inner Surface of the Hemisphere.

By slicing off one hemisphere to the level of the corpus callosum, a side view of the opposite hemisphere will be obtained, but to complete the study of the inner surface of the hemisphere a section of a hardened brain should be referred to.

The *inner surface of the hemisphere* (fig. 280) at its anterior part presents two large convolutions, the upper, the *marginal convolution* (1) (convolution of longitudinal fissure), and the lower, the *convolution of the corpus callosum* (2) or *gyrus fornicatus*, separated by the *calloso-marginal fissure* (C M) which reaches the margin of the hemisphere, and bounds the marginal convolution posteriorly.

The **gyrus fornicatus** (2) is a well-marked convolution which begins at the anterior perforated space in the base of the brain, and winds round the corpus callosum to the posterior, where it becomes continuous with the upper internal temporal convolution or uncinate gyrus. It becomes connected in its course with the superior frontal convolution, the quadrate lobe, the cuneus, and the middle occipito-temporal convolution. As it winds round the splenium of the cor-

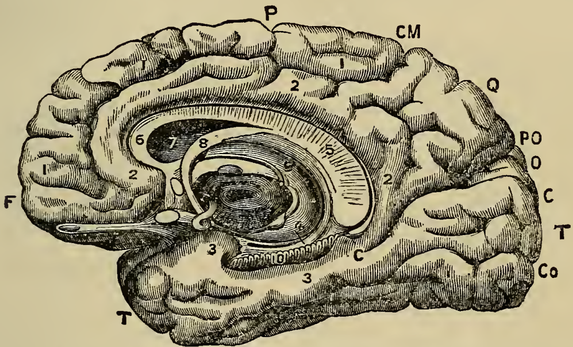


FIG. 280.—The inner and under surfaces of the brain to show the convolutions. F. Frontal lobe. P. Parietal lobe. Q. Quadrate lobe. O. Cuneus lobe. T, T. Temporal lobe. CM. Calloso-marginal fissure. PO. Parieto-occipital fissure. CC. Calcarine fissure. Co. Collateral fissure. 1, 1. Marginal convolution. 2, 2. Gyrus fornicatus. 3, 3. Uncinate gyrus. 4. Dentate convolution. 5. United corpus callosum and fornix. 6. Genu of corpus callosum. 7. Cavity of lateral ventricle. 8. Fornix. 9. Thalamus with corpora geniculata. 10. Fascia dentata in dentate fissure.

pus callosum it bounds the *fissure of the hippocampus* which forms the hippocampus major, hence this portion of the gyrus receives the name of *gyrus hippocampi*.

Posterior to the marginal convolution and continuous below with the *gyrus fornicatus* is the *quadrate lobe* (*precuneus*) (Q), which is separated from the *cuneus lobe* (O) by the *parieto-occipital fissure* (P O), a continuation of the fissure of the same name seen externally.

The **cuneus lobe** (O) is triangular in shape, and is placed between the parieto-occipital and the calcarine fissure (C) which separates it from the internal convolutions of the temporal lobe (T).

The **calcarine fissure** (C) of Huxley runs below the occipital lobe to the extremity of the gyrus fornicatus, being joined midway by the parieto-occipital fissure. It is an important fissure, since it

corresponds to the projection called the *hippocampus minor* in the posterior cornu of the lateral ventricle.

The **internal temporal convolutions** form the lower part of the inner wall of the hemisphere, and are continuous with those of the temporal lobe externally. The most important is the *uncinate gyrus* (3) which is immediately below the calcarine fissure and runs horizontally forward, becoming united with the gyrus fornicatus and passing in front of the fascia dentata. It then makes a sudden bend backward for half an inch, this hook-like process from which it derives its name becoming united with the tænia hippocampi.

The **collateral fissure** (Co) separates this last convolution from the inferior temporal convolutions, which are very irregular. It causes the prominence in the descending cornu of the lateral ventricle known as the *eminentia collateralis*.

The **dentate fissure** (10) is that immediately above the uncinate gyrus which lodges the *fascia dentata*, and corresponds to the *hippocampus major* in the descending cornu of the lateral ventricle. Immediately above this is a small *dentate convolution* (4), united with the tænia hippocampi, and continuous below with the uncinate gyrus.

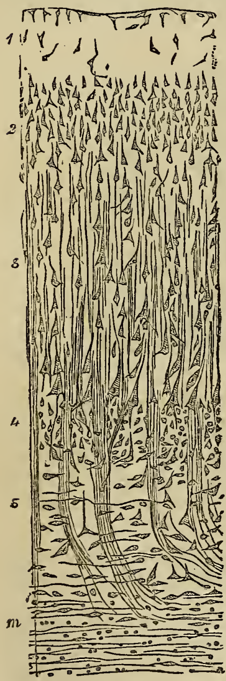


FIG. 281.—Section of grey cortex of a convolution. 1, 2, 3, 4, 5. The five layers described in the text. *m*. The white centre of the brain.

Structure of the Convolutions.

The convolutions are composed internally of white nerve matter continuous with that which forms the great bulk of the interior of the brain; externally they are covered by several superimposed layers of grey matter, each layer having certain characteristics which serve to distinguish it from its fellows. The layers vary in their number and depth in different brains and in different parts of the same brain, but in the parietal lobe it is easy with the microscope to distinguish that they are five in number; the following facts as to the structure of each layer are chiefly drawn from Meynert's description in Stricker's "Manual of Histology."

The *first* or *external* layer forms about one-tenth of the thickness of the cortex. It is pale in colour, and consists of a fine matrix containing connective-tissue elements, in which a few scattered stellate nerve cells are found, and near the surface numerous fine varicose nerve fibres, crossing each other in all directions.

The *second* layer, of about the same width, is made up of closely set small pyramidal nerve cells with branching process, the apex of the pyramid being a little drawn out, and in every instance directed towards the surface of the convolution.

The *third* layer is wider and paler than the second; it consists of large pyramidal cells separated into groups by the radiating fibres of the hemisphere.

The *fourth* layer is composed of small closely set angular corpuscles, placed irregularly, and imperfectly separated into groups.

The *fifth* is a layer of fusiform corpuscles which are placed vertically to the summit of a gyrus, but parallel to the surface of a sulcus.

With the unaided eye it is easy to note the alternation of whitish with reddish grey layers, but it is at all times difficult, even with the microscope, to ascertain the number of layers, or to define accurately the limits of each.

The Interior of the Cerebrum.

If the brain be placed upon its base, and the upper part of one hemisphere, at about one-third from its summit, be removed with a scalpel, a centre of white substance will be observed, surrounded by a narrow border of grey, which follows the line of the sulci and convolutions, and presents a zigzag form. This section, from exhibiting the largest surface of medullary substance demonstrable in a single hemisphere, is called *centrum ovale minus;* it is spotted by numerous small red points (puncta vasculosa), which are produced by the escape of blood from the cut ends of minute arteries and veins.

Separate carefully the two hemispheres of the cerebrum, and a broad band of white substance (corpus callosum) will be seen to connect them; it will be seen also that the surface of the hemisphere where it comes in contact with the corpus callosum, is bounded by a large convolution (gyrus fornicatus) which lies horizontally on that body, and may be traced forwards and backwards to the base of the brain, terminating by each extremity at the fissure of Sylvius. The sulcus between this convolution and the corpus callosum has been termed the "ventricle of the corpus callosum," and some longitudinal fibres (striæ longitudinales laterales), which are brought into view when the convolution is raised, were called by Reil the "covered band." If the upper part of each hemisphere be removed to a level with the corpus callosum, a large expanse of medullary matter, surrounded by a zigzag line of grey substance corresponding with the convolutions and sulci of the two hemispheres, will be seen; this is the *centrum ovale majus* of Vieussens.

The **corpus callosum** is a thick layer of fibres passing transversely between the two hemispheres, and constituting their *great commissure.* It is situated in the middle line of the centrum ovale majus, but nearer the anterior than the posterior part of the brain, and ends anteriorly in a rounded border, *genu*, which may be traced downwards to the base of the brain in front of the commis-

sure of the optic nerves; it here gives off two narrow white bands called *peduncles*, which diverge from each other and pass backwards across the substantia perforata to the fissure of Sylvius, where they terminate. Posteriorly it forms a thick rounded fold, *splenium*, which is connected on its under surface with the fornix; throughout the rest of its extent the corpus callosum is connected on its under surface with the septum lucidum. The length of the corpus callosum is about four inches.

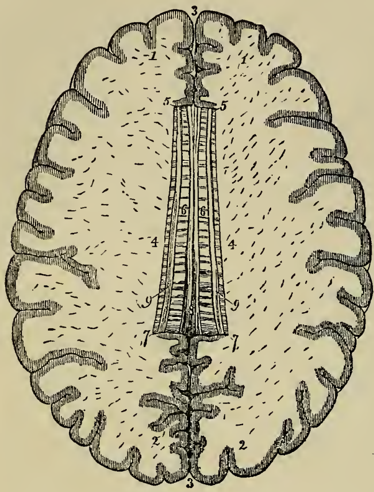


Fig. 282.—Section of the brain showing the centrum ovale majus and corpus callosum. 1, 1. Frontal lobes of the brain. 2, 2. Occipital lobes. 3, 3. Longitudinal fissure for the reception of the falx cerebri. 4, 4. Roof of the lateral ventricles. 5, 5. Genu of the corpus callosum. 6. Its body, upon which the lineæ transversæ are seen. 7, 7. Splenium. 8. Raphé. 9, 9. Striæ longitudinales laterales, or covered bands of Reil.

Beneath the posterior rounded border of the corpus callosum is the *transverse fissure* of the cerebrum, which extends between the hemispheres and crura cerebri from near the fissure of Sylvius on one side, to the same point on the opposite side of the brain. It is through this fissure that the pia mater communicates with the velum interpositum. And it was here that Bichat conceived the arachnoid to enter the ventricles; hence it is also named the *fissure of Bichat.*

Along the middle line of the corpus callosum is the *raphé*, a linear depression between two slightly elevated longitudinal bands (chordæ longitudinales Lancisii); and, on each side of the *raphé*, may be seen the *lineæ transversæ*, which mark the direction of the fibres of which the corpus callosum is composed. These fibres may be traced into the hemispheres on each side, and they will be seen to be crossed at about an inch from the raphé by the longitudinal fibres of the covered band of Reil. Anteriorly and posteriorly the fibres of the corpus callosum curve forwards and backwards into their corresponding lobes.

If a superficial incision be made through the corpus callosum on each side of the *raphé*, two irregular cavities will be opened, which extend from one extremity of the hemispheres to the other; these are the *lateral ventricles.* To expose them completely, their upper boundary should be removed with the scissors. In making this

dissection the thin and diaphanous membrane of the ventricles may frequently be seen.

Lateral Ventricles.—Each lateral ventricle is divided into a *central cavity* and three smaller cavities called *cornua*. The *anterior cornu* curves forwards and outwards in the anterior lobe; the *middle cornu* descends into the middle lobe; and the *posterior cornu* passes backwards in the posterior lobe, converging towards its fellow of the opposite side. The central cavity is triangular in form, being bounded above (*roof*) by the corpus callosum; internally by the septum lucidum, which separates it from the opposite ventricle; and below (*floor*) by the following parts, taken in their order of position from before backwards:—

Corpus striatum,	Choroid plexus,
Tenia semicircularis,	Corpus fimbriatum,
Thalamus opticus,	Fornix.

The **corpus striatum** is named from the striated lines of white and grey matter which are seen upon cutting into its substance. The portion of it which is seen in the lateral ventricle is the *intra-ventricular nucleus* or *nucleus caudatus*; it will be described with the extra-ventricular portion when the structures seen in a transverse section of the brain are under consideration.

The **tenia semicircularis** is a narrow band of white substance, extending along the posterior border of the corpus striatum, and serving as a bond of connection between that body and the thalamus opticus. It joins the anterior pillar of the fornix and is continued with it to the corpora albicantia. The tenia is partly concealed by a large vein (*vena corporis striati*), which receives numerous small veins from the corpus striatum and thalamus opticus, and terminates in the vena Galeni of its own side.

The **thalamus opticus** (*thalamus*, a bed) is an oblong body, having a thin coating of white substance on its surface; and has received its name from having the optic tract lying against its under surface. It is the inferior ganglion of the cerebrum. Part only of the thalamus is seen in the floor of the lateral ventricle; we must, therefore, defer its further description until we can examine it in its entire extent.

The **choroid plexus** (χόριον, εἶδος, resembling the chorion) is a vascular fringe extending obliquely across the floor of the lateral ventricle, and sinking into the middle cornu. Anteriorly, it is small and tapering, and communicates with the choroid plexus of the opposite ventricle, through a large oval opening, the *foramen of Monro*, or foramen commune anterius. This foramen may be seen by pulling slightly on the plexus, and pressing aside the septum lucidum with the handle of the knife. It is situated between the under surface of the fornix and the anterior extremities of the thalami optici, and forms a communication transversely between the lateral ventricles, and perpendicularly with the third ventricle.

The choroid plexus presents on its surface a number of minute

vascular processes, which are termed *villi.* They are covered by an epithelium consisting of a single layer of nucleated polygonal cells, which are ciliated in the embryo, but the cilia are absent in the adult. Besides the nucleus the cells contain numerous yellow granules and one or two dark oil-drops; and, according to Henle, give off from their angles spine-like processes, which are connected with the bed of homogeneous areolar tissue on which they rest. The vessels composing the plexus are connected by a transparent

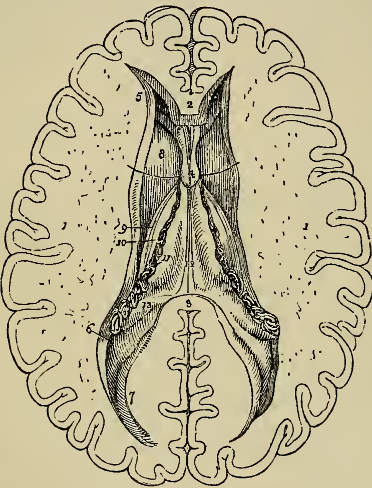


FIG. 283.—Lateral ventricles of the cerebrum. 1, 1. The two hemispheres cut down to a level with the corpus callosum so as to constitute the centrum ovale majus. The surface is seen to be studded with the small vascular points, puncta vasculosa; and surrounded by a narrow margin which represents the grey substance. 2. A small portion of the genu of the corpus callosum. 3. Splenium; the intermediate portion forming the roof of the lateral ventricles has been removed so as to expose completely those cavities. 4. Part of the septum lucidum, showing an interspace between its layers, the fifth ventricle. 5. Anterior cornu of one side. 6. Commencement of the middle cornu. 7. Posterior cornu. 8. Corpus striatum of one ventricle. 9. Tenia semicircularis. 10. Thalamus opticus. 11. Choroid plexus. This plexus communicates with that of the opposite ventricle through the foramen of Monro; a bristle is passed through this opening (under figure 4), and its extremities are seen resting on the corpus striatum at each side. The figure 11 rests on the edge of the fornix, on that part of it which is called corpus fimbriatum. 12. Fornix. 13. Commencement of the hippocampus major. The rounded oblong body, directly behind figure 13, is the pes accessorius, and farther back, immediately under figure 7, the hippocampus minor.

interstitial substance without areolar tissue; and the latter is often interspersed with calcareous particles. Sometimes the plexuses present on their surface an assemblage of small serous cysts.

The **corpus fimbriatum** is a narrow white band, situated internally to the choroid plexus, and extending with it into the descending cornu of the lateral ventricle. It is, in fact, the lateral thin edge of the fornix, and being attached to the hippocampus major in the descending horn of the lateral ventricle, is also termed *tenia hippocampi.*

The **fornix** is a white layer of medullary substance, of which a portion only is seen in this view of the ventricle.

The **anterior cornu** is triangular in form, sweeping outwards and

terminating by a point in the anterior lobe of the brain, at a short distance from its surface.

The **posterior cornu** curves inwards, as it extends back into the posterior lobe of the brain and likewise terminates near the surface. An elevation corresponding with the calcarine fissure on the inner surface of the hemisphere, projects into the area of this cornu, and is called the *hippocampus minor.*

The **middle** or **descending cornu,** in descending into the middle lobe of the brain, forms a very considerable curve, and alters its direction several times as it proceeds. Hence it is described as passing backwards and outwards and downwards, and then turning forwards and inwards. This complex expression of a very simple curve has given origin to a symbol, formed of the primary letters of the term, by which the student is enabled to recollect more easily the course of the cornu, BODFI. It is the largest of the three cornua, and terminates close to the fissure of Sylvius, after having curved around the crus cerebri.

The middle cornu should now be laid open, by inserting the little finger into its cavity, and making it serve as a director for the scalpel in cutting away the side of the hemisphere, so as to expose it completely.

The *superior boundary* of the middle cornu is formed by the under surface of the thalamus opticus, upon which are the two projections called corpus geniculatum internum and externum; and the *inferior wall* by the following parts:—

Hippocampus major,	Corpus fimbriatum,
Pes hippocampi,	Choroid plexus,
Pes accessorius,	Fascia dentata,

Transverse fissure.

The **hippocampus major** or **cornu ammonis,** so called from its resemblance to a ram's horn, the famous crest of Jupiter Ammon, is a considerable projection from the inferior wall, and extends the whole length of the middle cornu. Its extremity is likened to the foot of an animal, from its presenting a number of knuckle-like elevations on the surface, and is named *pes hippocampi.* The hippocampus major corresponds to the sulcus on the inner side of the gyrus fornicatus, as that convolution winds round beneath the genu of the corpus callosum to end in the uncinate gyrus. If the hippocampus be cut across, the section will be seen to resemble the extremity of a convoluted scroll, consisting of alternate layers of white and grey substance.

The **pes accessorius** (eminentia collateralis) is a swelling somewhat resembling the hippocampus major, but smaller in size, and situated in the angular interval between it and the hippocampus minor. It is formed by the protrusion of the sulcus described above as the *collateral fissure.*

The **corpus fimbriatum** (tenia hippocampi) is the narrow white band which is prolonged from the central cavity of the ventricle,

and is attached along the inner border of the hippocampus major. It is lost inferiorly in the hippocampus.

Fascia Dentata.—If the corpus fimbriatum be carefully raised, a narrow serrated band of grey substance, the margin of the grey substance of the middle lobe, will be seen beneath it; this is the fascia dentata. Beneath the corpus fimbriatum will be likewise seen the *transverse fissure* of the brain, which has been before described as extending from near the fissure of Sylvius on one side, across to the same point on the opposite side. It is through this fissure that the pia mater communicates with the *choroid plexus*, and the latter obtains its supply of blood. The fissure is bounded on one side by the corpus fimbriatum, and on the other by the under surface of the thalamus opticus.

Septum Lucidum.—The internal boundary of the lateral ventricle is the *septum lucidum.* This septum is thin, semi-transparent, and consists of two laminæ of cerebral substance attached above to the under surface of the corpus callosum at its anterior part, and below to the fornix. Each of these laminæ consists of white and grey matter, the white being situated on the surface looking towards the lateral ventricle, the grey matter nearer the middle line of the brain. Between the two layers is a narrow space, the *fifth ventricle*, which is lined by a proper membrane. The *fifth ventricle* may be shown, by snipping through the septum lucidum transversely with the scissors.

The corpus callosum should now be cut across towards its anterior extremity, and the two ends carefully dissected away. The anterior portion will be retained only by the septum lucidum, but the posterior will be found incorporated with the white layer beneath, which is the fornix.

Fornix.—The fornix (arch) is an arched band of white substance, placed in the floor of the lateral ventricle, and intimately connected posteriorly with the under surface of the corpus callosum. It consists of two lateral halves which unite in the middle of the lateral ventricle forming the *body*, but diverge from each other posteriorly as the *posterior peduncles*, and anteriorly as the *anterior peduncles* or *crura.* The two crura descend in a curved direction to the base of the brain, embedded in grey substance in the lateral walls of the third ventricle, and lying directly behind the anterior commissure. At the base of the brain they make a sudden curve upon themselves and constitute the *corpora albicantia*, from which they may be traced upwards to the thalami optici. Opening transversely beneath these two crura, just as they are about to arch downwards, is the foramen of communication between the lateral and the third ventricle, the *foramen of Monro;* or *foramen commune anterius.* The choroid plexuses communicate, and the veins of the corpora striata pass through this opening.

The lateral thin edges of the fornix are continuous *posteriorly* with the concave border of the hippocampus major at each side, and form the narrow white band called *corpus fimbriatum.* In the middle

line the fornix lies in contact with the corpus callosum, and posteriorly its fibres are continued on to the surface of the hippocampus major and minor.

The fornix may now be removed by dividing it across anteriorly, and turning it backwards, at the same time separating its lateral connections with the hippocampi. On examining its under surface it will be noticed that where the posterior peduncles diverge from each other they expose the fibres of the corpus callosum; these are for the most part transverse, but some few have a longitudinal direction. The appearance presented by the lateral bars formed

FIG. 284.—Vertical longitudinal section of the brain. 1. Marginal convolution. 2. Gyrus fornicatus. 3. Velum interpositum. 4. Corpus callosum. 5. Peduncle of pineal gland on the margin of optic thalamus. 6. Septum lucidum. 7. Middle commissure of third ventricle. 8. Fornix. 9. Pineal gland. 10. Foramen of Monro. 11. Fissure of Bichat. 12. Anterior commissure. 13. Corpora quadrigemina. 14. Posterior commissure. 15. Valve of Vieussens. 16. Iter a tertio ad quartum ventriculum. 17. Fourth ventricle. 18. Optic nerve. 19. Arbor vitæ cerebelli. 20. Pituitary body and infundibulum. 21. Section of medulla oblongata. 22. Corpus albicantium. 24. Locus perforatus posticus. 26. Section of pons Varolii.

by the fornix and the transverse and longitudinal lines of the corpus callosum, has been named the *lyra* from a fancied resemblance to a harp.

Velum Interpositum.—Beneath the fornix is the *velum interpositum* (tela choroidea), a fold of pia mater introduced into the interior of the brain through the transverse fissure. The velum is continuous at each side with the choroid plexus, and contains in its inferior layer two large veins (the *venæ Galeni*) which receive the blood from the corpora striata and choroid plexuses, and terminate posteriorly, after uniting into a single trunk, in the straight sinus. On the under surface of the velum interpositum are two fringe-

like bodies, which project into the third ventricle. These are the *choroid plexuses* of the *third ventricle;* posteriorly, these fringes enclose the pineal gland. The velum interpositum is coated with an epithelium identical with that of the choroid plexuses; and around the pineal gland the areolar tissue is abundant and strong.

If the velum interpositum be raised and turned back, an operation to be conducted with care, particularly at its posterior part, where it invests the pineal gland, the thalami optici and the cavity of the third ventricle will be brought into view.

Thalami Optici.—The thalami optici are two oval bodies, of a white colour superficially, inserted between the two diverging portions of the corpora striata, and resting upon the upper surface of the crura cerebri. In the middle line a fissure exists between them which is called the *third ventricle.* Posteriorly and inferiorly, they form the superior wall of the descending cornu of the lateral ventricle, and present two rounded elevations called *corpus geniculatum externum* and *internum.* The *corpus geniculatum externum,* the larger of the two, and of a greyish colour, is the principal origin of the optic nerve. Anteriorly, the thalami are connected with the corpora albicantia by means of two white bands, which are the terminations of the crura of the fornix. Externally they are in relation with the corpora striata and hemispheres. In their interior the thalami are composed of masses of grey matter with white fibres intermixed. They are essentially the *inferior ganglia of the cerebrum.*

Third Ventricle.—The third ventricle is the fissure between the two thalami optici. It is bounded above by the under surface of the velum interpositum, from which are suspended the choroid plexuses of the third ventricle, and is separated by the velum from the body of the fornix. Its *floor* is formed by the lamina cinerea, the tuber cinereum, corpora albicantia, and locus perforatus posticus. *Laterally* it is bounded by the thalami optici; *anteriorly* by the anterior commissure and crura of the fornix; and *posteriorly* by the posterior commissure and the iter a tertio ad quartum ventriculum. The third ventricle is crossed by three commissures, anterior, middle, and posterior; and communicates by two openings called foramen commune anterius and foramen commune posterius, with the lateral and fourth ventricles.

The **anterior commissure** is a small rounded white cord, which connects the corpora striata of the two sides, and reaches the substance of the hemispheres; it lies immediately in front of the crura of the fornix, and is united by its anterior margin with the septum lucidum. The **middle** or **soft commissure** consists of grey substance, which is continuous with the grey lining of the ventricle; it connects the adjacent sides of the thalami optici. The **posterior commissure,** smaller than the anterior, is a flattened white cord, connecting the two thalami optici posteriorly; it is placed beneath the peduncles of the pineal gland near their origin, and has beneath it the aqueduct of Sylvius.

The space between the anterior and middle commissure is called the *foramen commune anterius*, and is that to which the name of Monro has been given (foramen of Monro). It is the medium of communication between the two lateral and third ventricles, and transmits superiorly the choroid plexus and veins of the corpus striatum. If the crura be slightly separated, the anterior commissure will be seen immediately in front of them, crossing from one corpus striatum to the other. The space between the middle and posterior commissure is the *foramen commune posterius;* it is much shallower than the preceding, and is the origin of a canal, the *aqueduct of Sylvius*, or *iter a tertio ad quartum ventriculum*, which leads back-

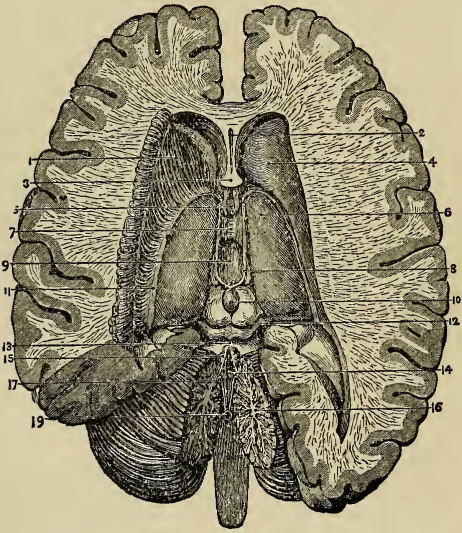


Fig. 285.—Third ventricle of brain. 1. Corpus striatum dissected. 2. Fifth ventricle. 3. Anterior crura of fornix (cut). 4. Corpus striatum. 5. Anterior commissure of third ventricle. 6. Optic thalamus. 7. Middle or soft commissure. 8. Peduncles of pineal gland. 9. Third ventricle. 10. Pineal gland. 11. Tænia semicircularis. 12. Corpora quadrigemina. 13. Valve of Vieussens. 14. Fourth ventricle. 15. Anterior extremity of superior vermiform process. 16. Arbor vitæ cerebelli. 17. Anterior extremity of inferior vermiform process (nodulus). 19. Communication of fourth ventricle with sub-arachnoid space.

wards beneath the posterior commissure and through the base of the corpora quadrigemina to the upper part of the fourth ventricle.

Corpora Quadrigemina.—The corpora quadrigemina, or optic lobes, are situated immediately behind the third ventricle and posterior commissure, and beneath the posterior border of the corpus callosum. They form, indeed, at this point, the inferior boundary of the transverse fissure of the hemispheres. The anterior pair of these bodies, grey in colour, are named *nates;* the posterior pair, white and much smaller than the anterior, are termed *testes*. From the nates on each side may be traced a rounded process (brachium anterius) which passes obliquely outwards into the thalamus opticus; and from the testis a similar but smaller process (brachium posterius) which has the same destination. The corpus geniculatum internum

lies in the interval of these two processes where they enter the thalamus, and behind the brachium posterius is a prominent band which marks the course of the superior division of the olivary fasciculus. The corpora quadrigemina are perforated longitudinally through their base by the aqueduct of Sylvius ; they are covered in partly by the pia mater and partly by the velum interpositum, and the nates support the pineal gland. Two large white bands pass down from them to the cerebellum, forming the *processus e cerebello ad testes*, the great bond of connection between the great and little brain.

Pineal Gland.—The pineal gland (epiphysis cerebri) is a small reddish-grey body of a conical form (hence its synonym *conarium*), situated on the anterior part of the nates, and invested by a duplicature of pia mater derived from the under part of the velum interpositum. The pineal gland, when pressed between the fingers, is found to contain a gritty matter (acervulus) composed chemically of phosphate and carbonate of lime, and phosphate of magnesia and ammonia, with some organic matter; it also contains amyloid bodies. It is hollow in the interior forming two cavities, which often communicate with the third ventricle. It is connected to the brain by means of two cords of white matter called *peduncles* and a thin lamina derived from the posterior commissure; the peduncles of the pineal gland are attached to the thalami optici, and may be traced along the upper and inner margin of those bodies to the crura of the fornix with which they become blended. From the close connection subsisting between the pia mater and the pineal gland, and the softness of texture of the latter, the gland is liable to be torn away in the removal of the pia mater.

Behind the corpora quadrigemina is the cerebellum, and beneath the cerebellum the fourth ventricle. The student must therefore divide the cerebellum down to the fourth ventricle, and turn its lobes aside to examine that cavity.

Fourth Ventricle.—The fourth ventricle is the ventricle of the cerebellum. It is situated on the posterior surface of the medulla oblongata and pons Varolii, is diamond-shaped in its form, and *bounded on each side* by a thick cord passing between the cerebellum and corpora quadrigemina, called the *processus e cerebello ad testes*, and by the *restiform body* and *posterior pyramids*. It is covered in *behind* by the inferior vermiform process of the cerebellum, and by a thin lamella of medullary substance, stretched between the two processus e cerebello ad testes, termed the *valve of Vieussens.*

That portion of the cerebellum which forms the posterior boundary of the fourth ventricle presents four small prominences or lobules, and a thin layer of medullary substance, the *velum medullare posterius*. Of the lobules two are placed in the middle line, the *nodulus* and *uvula*, the former being before the latter; the remaining two are named *amygdalæ*, or tonsils, and are situated one on either side of the uvula. They all project into the cavity of the fourth ventricle, and the velum medullare posterius is situated in front of

them. The *valve of Vieussens* or velum medullare anterius is an extremely thin lamella of medullary substance, prolonged from the white matter of the cerebellum to the testes, and attached on each side to the processus e cerebello ad testes. This lamella is overlaid for a short distance by a thin, transversely grooved lobule of grey substance (linguetta laminosa) derived from the anterior border of the cerebellum, and its junction with the testes is strengthened by a narrow slip given off by the commissure of those bodies, the *frænulum veli medullaris anterioris.* The *anterior wall*, or *floor* of the fourth ventricle, is formed by two slightly convex bodies, *fasciculi teretes*, separated by a longitudinal groove which is continuous

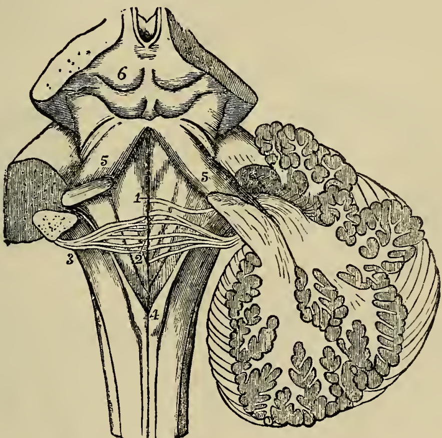


Fig. 286.—1. Median groove of the fourth ventricle, with the fasciculi teretes, one on each side. 2. The lineæ transversæ and origin of the auditory nerve. 3. The restiform body. 4. The posterior pyramid; the figure is placed on the enlargement called *processus clavatus.* 5. The processus e cerebello ad testes. 6. The corpora quadrigemina.

inferiorly with the posterior median fissure of the spinal cord. On these bodies the grey substance (fasciolæ cinereæ) derived from the interior of the medulla is spread out, and at the lower part of the ventricle forms several eminences or nuclei, from which, according to Stilling, the eighth and ninth nerves, and probably also the fifth, take their origin. Higher up, the fasciculi teretes are crossed by several white striæ (lineæ transversæ), the origin of the auditory nerves. Upon the lower part of the floor of this ventricle is an impression resembling the point of a pen, and hence named *calamus scriptorius;* the lateral boundaries of the calamus are the processus clavati of the posterior pyramids. *Above*, the fourth ventricle is bounded by the corpora quadrigemina and aqueduct of Sylvius; and *below* by a layer of pia mater and arachnoid, called the valve of the

arachnoid. Beneath this valve a communication exists between the ventricles of the brain and the sub-arachnoid space. Within the fourth ventricle, and lying against the uvula and tonsils, are two small vascular fringes formed by the pia mater, the *choroid plexuses* of the fourth ventricle.

Transverse Section of the Cerebrum.

Transverse vertical sections of the cerebrum at different levels are useful for the purpose of ascertaining the relative position of the structures in the interior, and more especially for determining the relation which the two great basal ganglia, the thalamus opticus and corpus striatum, bear to each other and to surrounding parts. The figure here given (fig. 287) is taken from a recent section of the

Fig. 287.—Transverse vertical section of the cerebrum made immediately behind the corpora albicantia. 1. Longitudinal fissure. 2. Corpus callosum. 3. Fornix. 4. Island of Reil. 5. Nucleus caudatus. 6. Internal capsule. 7. External capsule. 8. Tenia-form nucleus or claustrum. 9. Lenticular nucleus. 5, 6, 7, 8, and 9 together constitute the corpus striatum. 10. Thalamus opticus. 11. Third ventricle. 12. Crus cerebri. 13. Corpora albicantia. 14. Tuber cinereum and commencement of infundibulum. 15. Optic tract. 16. Extremity of middle horn of lateral ventricle.

brain, which has been made immediately behind the corpora albicantia; it passes through the lateral and third ventricles, the middle horn of the lateral ventricles, island of Reil, thalamus opticus, fornix, and corpus striatum. The latter is now seen to be a composite body made up of several independent nuclei; its full description is as follows.

The **corpora striata** are two pyriform bodies placed with their broad ends forwards and their narrow ends backwards. They are throughout the greater part of their extent embedded in the substance of the hemispheres, but their anterior extremities come to the surface in the body and anterior horn of the lateral ventricles; they are thus divisible into an *intraventricular* and an *extraventricular* portion. The intraventricular portion is named *nucleus caudatus;* the nuclei on the two sides diverge from each other as they proceed backwards, and pass to the outer side of each thalamus, which they thus come to embrace. The extraventricular portion lies to the outer side of the optic thalamus, and between it and the island of Reil; it is chiefly formed by a large nucleus, which on horizontal section presents the appearance of a biconvex lens, hence it has been named the *lenticular nucleus.* In a transverse vertical section this nucleus appears triangular, with the base directed outwards and the apex inwards; the grey matter which forms its bulk is streaked by numerous white fibres which radiate as they pass through it into the convolutions. On the inner side the lenticular nucleus is separated from the nucleus caudatus and thalamus opticus by a strand of white matter called the *external capsule*, and on the outer side a similar but less marked band called *internal capsule* lies between it and the island of Reil; a grey streak in the middle of the latter has been named the *teniaform nucleus* or *claustrum.*

Lining Membrane of the Ventricles.

The lining membrane of the ventricles, *ependyma ventriculorum*, is a serous layer distinct from the arachnoid; it lines the whole of the interior of the lateral ventricles, and is connected above and below with the attached border of the choroid plexus, so as to exclude all communication between the lateral ventricles and the exterior of the brain. From the lateral ventricles it is reflected through the foramen of Monro on each side into the third ventricle, which it invests throughout. From the third it is conducted into the fourth ventricle, through the iter a tertio ad quartum ventriculum, and after lining its interior becomes continuous inferiorly with the sub-arachnoid tissue of the spinal cord. The lining membrane of the ventricles is provided with a ciliated epithelium, and is the source of the secretion which moistens and lubricates their interior. The fifth ventricle has a separate lining membrane.

The epithelium of the ependyma ventriculorum is supported by a delicate layer of modified connective tissue, similar to that described in the spinal cord under the name of neuroglia. Where the sub-ependymic tissue is thickened, certain small bodies, *amyloid bodies*, are found as a pathological formation. These bodies resemble starch-granules, are round and biscuit-shaped, yellowish in colour, and marked by concentric striæ.

cells of cerebellum are flask shaped

CEREBELLUM.

The cerebellum, seven times smaller than the cerebrum, is situated beneath the posterior cerebral lobes, being lodged in the posterior fossa of the base of the cranium, and protected from the superincumbent pressure of the cerebrum by the tentorium cerebelli. Like the cerebrum, it is composed of grey and white substance, the former occupying the surface, the latter the interior, and its surface is formed of parallel lamellæ separated by sulci, and here and there by deeper sulci. In form, the cerebellum is oblong and flattened, its greater diameter being from side to side, its two surfaces looking upwards and downwards, and its borders being anterior, posterior, and lateral. In consideration of its shape the cerebellum admits of a division into two hemispheres, into certain prominences termed processes and lobules, and into certain divisions of its substance called lobes, formed upon the hemispheres by the deeper sulci above referred to. The two hemispheres are separated from each other on the upper surface of the cerebellum by a longitudinal ridge, which is termed the *superior vermiform process*, and which forms a commissure between them. On the anterior border of the organ there is a semilunar notch, *incisura cerebelli anterior*, which embraces the corpora quadrigemina. On the posterior border there is another notch, *incisura cerebelli posterior*, which receives the upper part of the falx cerebelli; and on the under surface of the cerebellum is a deep fissure corresponding with the medullâ oblongata, and termed the *vallecula* (valley).

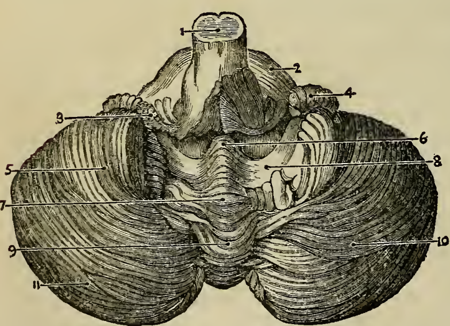


Fig. 288.—Under surface of cerebellum, the amygdalæ having been removed. 1. Medulla oblongata. 2. Pons Varolii. 3. Choroid plexus of the fourth ventricle. 4. Flocculus. 5. Biventral lobe of cerebellum. 6. Nodulus of inferior vermiform process. 7. Uvula. 8. Posterior medullary velum. 9. Pyramid. 10. Slender lobe. 11. Posterior inferior lobe.

Each hemisphere of the cerebellum is divided by means of a fissure (sulcus horizontalis) which runs along its free border into an upper and a lower portion, and upon each of these portions certain lobes are marked out. Thus on the upper portion there are two such lobes separated by a sulcus, somewhat more strongly marked than the rest, and extending deeper into the substance of the cerebellum; they are the *anterior superior lobe* and *posterior superior lobe*. On the under portion of the hemisphere there are three such lobes, namely,

the *posterior inferior lobe*, the *slender* (*gracilis*) *lobe*, and the *biventral* or *digastric lobe*, and two additional ones of peculiar form, the lobus inferior internus or *tonsil*, and the *flocculus*. The *tonsil* (amygdala) is situated on the side of the vallecula, and projects into the fourth ventricle. The *flocculus* or pneumogastric lobule, long and slender, extends from the side of the vallecula around the restiform body to the crus cerebelli, lying behind the filaments of the eighth pair of nerves.

The commissure between the two hemispheres is termed the *worm* (vermis), that portion of the worm which occupies the upper surface of the cerebellum as far back as the horizontal fissure being the processus vermiformis superior, and that which is lodged within the vallecula being the processus vermiformis inferior. The *superior vermiform process* is a prominent longitudinal ridge, extending from the incisura anterior to the incisura posterior. In imitation of the hemispheres, it is divided into lobes, of which three have received names—namely, the *lobulus centralis*, a small lobe situated in the incisura anterior; the *monticulus cerebelli*, a longer lobe, having its peak and declivity; and a small lobe near the incisura posterior, the *commissura simplex*. The lobes of the *inferior vermiform* process are four in number, namely, the *commissura brevis*, situated in the incisura posterior, below the horizontal fissure; the *pyramid*, a small obtusely-pointed eminence; a larger prominence, the *uvula*, situated between the tonsils, and connected with them by means of a commissure; and in front of the uvula, the *nodulus*. In front of the nodulus is a thin lamina of medullary substance consisting of a central and two lateral portions, the *velum medullare posterius*, and between this velum and the nodulus and uvula is a deep fossa which is known as the *swallow's nest* (nidus hirundinis). The *velum medullare anterius* is the valve of Vieussens, described with the fourth ventricle; both these vela proceed from the same point in the roof of that ventricle, and separate from each other at an angle, the one passing obliquely forwards, the other obliquely backwards.

When a vertical incision is made into the cerebellum, that appearance is seen which has been denominated *arbor vitæ cerebelli;* the white substance in the centre of such a section resembles the trunk of a tree, from which branches are given off, and from the branches branchlets and leaves, the two latter being coated by a moderately thick and uniform layer of grey substance. If the incision be made somewhat nearer to the commissure than to the lateral border of the organ, a yellowish-grey dentated line, enclosing medullary substance traversed by the openings of numerous vessels, will be seen in the centre of the white substance. This is the ganglion of the cerebellum, the *corpus dentatum*, from which the peduncles of the cerebellum proceed. The reddish-grey line is dense and horny in structure, and is the cut edge of a thin capsule, open towards the medulla oblongata.

The cerebellum is associated with the rest of the encephalon by

means of three pairs of rounded cords or peduncles, superior, middle, and inferior. The superior peduncles, or *processus e cerebello ad testes*, proceed from the cerebellum forwards and upwards to the testes, in which they are lost. They form the anterior part of the lateral boundaries of the fourth ventricle, and give attachment by their inner borders to the valve of Vieussens, which is stretched between them. At their junction with the testes they are crossed by the fourth pair of nerves. The middle peduncles, or *crura cerebelli ad pontem*, the largest of the three, issue from the cerebellum through the anterior extremity of the sulcus horizontalis, and are lost in the pons Varolii. The inferior peduncles, or *crura ad medullam oblongatam*, are the restiform bodies, which descend to the posterior part of the medulla oblongata, and form the inferior portion of the lateral boundaries of the fourth ventricle.

Structure of the Cerebellum.

The cerebellum, like the cerebrum, is composed internally of white and externally of grey nerve matter, the latter preponderating and being arranged around the former in such a manner as to present the appearance described above as the *arbor vitæ*. The *grey cortex* is divisible into an outer and an inner layer, the outer being of a clear grey colour, and the inner greyish-red and granular in appearance. The outer layer consists of a delicate matrix supporting fibres and cells, the fibres running for the most part at right angles to the surface of the cerebellum, and the cells being very small, scattered, granule-like bodies. The inner layer is formed also of granule-like cells very closely aggregated, and embedded in a gelatinous matrix. Between the inner and outer layers is a single layer of peculiar cells called *cells of Purkinje;* they are chiefly flask-shaped, and give off numerous processes both to the inner and outer layers, those to the latter being more numerous, larger, and more extensively ramified than those to the former.

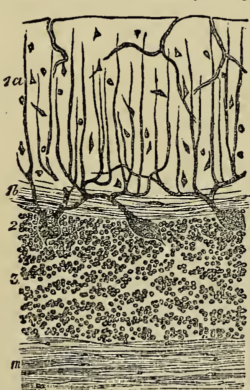


FIG. 289.—1*a*. External and, 1*b*, Internal portions of the outer grey layer. 2. Layer of cells of Purkinje. 3. Inner layer. *m*. Medullary layer.

ARTERIES OF THE CEREBRUM.

The arteries of the brain present certain peculiarities which render it necessary that they should be studied apart from the general arterial system and along with the organ to which they are distributed. The important anastomotic connection at the base of the

brain called the *circle of Willis* has been described on a previous page (394), and it is only necessary here to recall the fact that from that circle three main trunks, called *anterior*, *middle*, and *posterior cerebral* arteries, are given off on each side to the anterior, middle, and posterior regions of the brain. The branches derived from these trunks are of two kinds: *medullary*, which pass to the basal ganglia and neighbouring parts; and *cortical*, which are distributed to the convolutions of the five lobes into which the cerebrum is divided. These two systems of arteries are almost entirely independent of each other, what communications exist between them being very few in number, and of capillary minuteness; the individual branches also of each system are distributed to independent areas, and only communicate with their fellows at the margins of those areas by few and small communications, hence they are distinguished as *end arteries.* As a necessary result of this arrangement, one artery cannot take the place or perform the work of another, as we so often find to be the case in other parts of the body, but if an artery becomes plugged, the area to which it is distributed becomes deprived of nourishment and rapidly undergoes degeneration. The following is a brief description of the chief branches of the three arteries mentioned above.

Anterior Cerebral.—The *medullary* branches of this trunk are few in number; they are given off close to its origin from the internal carotid, pass through the anterior part of the substantia perforata, and are distributed to the front of the corpus striatum, and genu of the corpus callosum. The *cortical* branches are four in number. The first of these is distributed to the internal orbital convolutions; the second to the anterior part of the marginal convolution, the anterior part of the middle frontal convolution, and to the superior frontal convolution; the third to the inner surface of the hemisphere as far back as the ascending portion of the calloso-marginal fissure. The fourth supplies the quadrate lobe, and gives off a branch which enters the corpus callosum and supplies its structure.

Middle Cerebral.—This is the largest artery of the three, and from its position is frequently named the **Sylvian artery.** The *medullary* branches are numerous; they enter the openings in the substantia perforata, and passing directly upwards are distributed to the extraventricular nuclei of the corpus striatum, and the back part of the nucleus caudatus. The main trunk of the middle cerebral passes upwards in the fissure of Sylvius, and as it lies against the island of Reil divides into four *cortical* branches. The first of these is distributed to the outer part of the orbital surface and inferior frontal convolution; the second to the posterior part of the middle frontal and three-fourths of the ascending frontal convolution; the third to the rest of the ascending frontal, ascending parietal, and anterior part of the superior parietal, and the fourth to the inferior parietal (supra-marginal) and superior temporo-sphenoidal convolution.

Posterior Cerebral.—Most of the *medullary* branches of this artery enter the locus perforatus posticus, but a few are given off on the outer side of the crus cerebri; both sets are distributed to the thalamus opticus, crus cerebri, and corpora quadrigemina. The *cortical* branches are three in number; the first passes to the anterior part of the uncinate gyrus, the second to the back part of the same convolution and the lower part of the temporo-sphenoidal lobe, and the third to the occipital lobe.

MEMBRANES OF THE ENCEPHALON.

Dissection.—To examine the encephalon with its membranes, the upper part of the skull must be removed, by sawing through the external table and breaking the internal table with the chisel and hammer. After the calvarium has been loosened all round, it will require a considerable degree of force to tear the bone away from the dura mater. This adhesion is particularly firm at the sutures, where the dura mater is continuous with a membraneous layer interposed between the edges of the bones; in other situations the connection results from numerous vessels which permeate the inner table of the skull. The adhesion subsisting between the dura mater and bone is greater in the young subject and in old persons than in the adult. On being torn away, the internal table will present numerous deeply grooved and ramified channels, corresponding with the branches of the meningeal arteries. Along the middle line will be seen a groove corresponding with the superior longitudinal sinus, and on either side may be frequently observed some small fossæ, corresponding with the Pacchionian bodies.

The membranes of the encephalon and spinal cord are—the *dura mater*, *arachnoid membrane*, and *pia mater*.

The **dura mater** is the firm whitish or greyish layer which is brought into view when the calvarium is removed. It is a strong fibrous membrane, somewhat laminated in texture, and composed of white fibrous tissue. Lining the interior of the cranium, it serves as the internal periosteum of that cavity; it is prolonged also into the spinal column, but is not adherent to the bones in that canal as in the cranium. From the internal surface of the dura mater, processes are directed inwards for the support and protection of parts of the brain; while from its exterior, other processes are prolonged outwards to form sheaths for the nerves as they quit the skull and spinal column. Its external surface is rough and fibrous, and corresponds with the internal table of the skull. The internal surface is smooth, and lined by epithelium; it was formerly regarded as a reflected layer of the arachnoid membrane.

On the external surface of the dura mater the branches of the middle meningeal artery may be seen ramifying; and in the middle line is a depressed groove, formed by the subsidence of the upper wall of the superior longitudinal sinus. If the sinus be opened along its course, it will be found to be a triangular channel, crossed

at its lower angle by numerous white bands, called chordæ Willisii ; granular bodies are also occasionally seen in its interior, these are the glandulæ Pacchioni.

The **glandulæ Pacchioni** are small, round, whitish granulations, occurring singly or in clusters, and forming small groups of various size along the margin of the longitudinal fissure of the cerebrum, and more particularly near the summit of the latter. They are absent in infancy, increase in numbers in adult life, and are abundant in the aged. They are simply enlarged villi of the arachnoid, and consist of a spongy tissue continuous with the sub-arachnoid

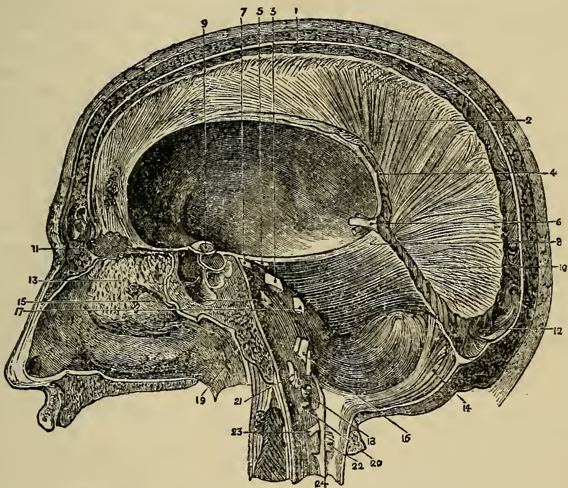


FIG. 290.—Sinuses and membranes of the brain (side view). 1. Superior longitudinal sinus. 2. Falx cerebri. 3. Fifth nerve. 4. Inferior longitudinal sinus. 5. Fourth nerve. 6. Venæ Galeni. 7. Third nerve. 8. Tentorium cerebelli. 9. Second nerve. 10. Straight sinus. 11. Crista galli of ethmoid. 12. Torcular Herophili. 13. First nerve. 14. Falx cerebelli. 15. Sixth nerve. 16. Eighth nerve. 17. Seventh nerve. 18. Vertebral artery. 19. Eustachian tube. 20. First cervical nerve. 21. Ninth nerve. 22. Posterior root of second cervical nerve. 23. Anterior root of second cervical nerve. 24. Ligamentum denticulatum.

tissue and of the same composition, covered by a layer of epithelial cells. As they push the dura mater before them in the process of their growth they obtain from it a thin membrane which spreads over them to form an outer coat. When of large size they cause absorption of the bone and so come to be lodged in depressions or pits in the interior of the vertex of the skull.

If the student cut through one side of the dura mater, in the direction of his incision through the skull, and turn it upwards towards the middle line, he will observe the smooth internal surface of this membrane. He will perceive also the large veins of the

hemispheres filled with dark blood, and passing from behind forwards to open into the superior longitudinal sinus. If he introduce the handle of his scalpel between the dura mater and arachnoid, he will see a vertical layer of the former descending between the hemispheres; and if he draw one side of the brain a little outwards, he will be enabled to perceive the extent of the process of membrane which is called the falx cerebri.

The processes of dura mater which are sent inwards towards the interior of the skull are the *falx cerebri*, *tentorium cerebelli*, and *falx cerebelli*.

The **falx cerebri** (*falx*, a sickle, so named from its sickle-like appearance), narrow in front, broad behind, and forming a sharp curved edge below, is attached in front to the crista galli process of the ethmoid bone, and behind to the tentorium cerebelli; between these points it is connected with the inner surface of the cranium in the middle line. Along the attached border runs the superior longitudinal sinus, and along the free edge the inferior longitudinal sinus, these vessels being situated between the two fibrous layers of which the membrane is composed.

The **tentorium cerebelli** (*tentorium*, a tent) is a roof of dura mater, thrown across the cerebellum and attached at each side to the margin of the petrous portion of the temporal bone; behind, to the transverse ridge of the occipital bone, which lodges the lateral sinuses; and in front to the upper border of the petrous portion of the temporal bone and to the clinoid processes. It supports the posterior lobes of the cerebrum and prevents their pressure * on the cerebellum, leaving a small opening anteriorly, for the transmission of the crura cerebri. Its attached border contains the lateral and superior petrosal sinuses, and the junction between it and the falx cerebri is channelled by the straight sinus.

The **falx cerebelli** is a small process, generally double, attached to the vertical ridge of the occipital bone beneath the lateral sinus, and to the tentorium. It lodges the occipital sinuses and is received into the indentation between the two hemispheres of the cerebellum.

Removal of the Brain.—The student cannot see the tentorium and falx cerebelli until the brain is removed; but he should consider the attachments of the former on the dried skull, for he will have to incise it in the removal of the brain. He should now proceed to that operation, for which purpose the dura mater is to be divided, all round, on a level with the section through the skull, and the scissors are to be carried deeply between the hemispheres of the brain in front, to cut through the anterior part of the falx; then draw the dura mater backwards, and leave it hanging by its attachment to the tentorium. Raise the anterior lobes of the brain carefully with the hand, and lift the olfactory bulbs from the cribriform fossæ with the handle of the scalpel. Then cut across the two optic nerves and internal carotid arteries. Next divide

* In leaping animals, as the feline and canine genera, the tentorium is formed of bone.

the infundibulum and third nerves, and carry the knife along the margin of the petrous bone at each side, so as to divide the tentorium near its attachment. Cut across the fourth, fifth, sixth, seventh, and eighth nerves in succession with a sharp knife, and pass the scalpel as far down as possible into the vertebral canal, to sever the spinal cord, cutting first to one side, and then to the other, in order to divide the vertebral arteries and first cervical nerves. Then let him press the cerebellum gently upwards with the fingers of the right hand, the hemispheres being supported with the left, and the brain will roll into his hand.

The **arteries** of the dura mater are—the *anterior meningeal* from the ethmoidal, ophthalmic, and internal carotid. The *middle meningeal* and *meningea parva* from the internal maxillary. The *inferior meningeal* from the ascending pharyngeal and occipital artery; and the *posterior meningeal* from the vertebral.

Its **nerves** are derived from the nervi molles and superior cervical ganglion of the sympathetic, from the Gasserian ganglion, the ophthalmic nerve, and sometimes from the fourth and eighth. The branches from the ophthalmic and fourth are given off while those nerves are situated by the side of the sella turcica; they are recurrent, and pass backwards between the layers of the tentorium, to the lining membrane of the lateral sinus.

Kölliker describes the dura mater as composed of two lamellæ, *periosteal* and *proper fibrous;* the former adheres to the bones, the latter forms the internal processes, whilst the sinuses result from the separation of the two. He finds nothing to indicate the lining of the internal surface by the arachnoid as a separate membrane; but shows that the tesselated epithelium of the free surface is in contact with and bedded upon the fibrous structure.

The space between the dura mater and arachnoid is called the *sub-dural space;* it was formerly known as the cavity of the arachnoid.

The **arachnoid** (*ἀράχνη εἶδος,* like a spider's web) is a delicate membrane which invests the brain externally to the pia mater. On the upper surface of the hemispheres it is transparent, but may be demonstrated as it passes across the sulci from one convolution to another by injecting with a blow-pipe a stream of air beneath it. At the base of the brain the membrane is opalescent and thicker than in other situations, and more easily demonstrable from the circumstance of stretching across the interval between the temporal lobes of the hemispheres. The space which is included between this layer of membrane and those parts of the base of the brain which are bounded by the optic commissure and fissures of Sylvius in front, and the pons Varolii behind, is termed the *anterior sub-arachnoid space.* Another space formed in a similar manner between the under part of the cerebellum and the medulla oblongata, is the *posterior sub-arachnoid space;* and a third space, situated over the corpora quadrigemina, may be termed the *superior sub-arachnoid space.* These spaces communicate freely with each other, the anterior

and posterior across the crura cerebelli, the anterior and the superior around the crura cerebri, and the latter and the posterior across the cerebellum in the course of the vermiform processes. The posterior space communicates by means of an opening called the *foramen of Magendie* with the cavity of the fourth ventricle ; and the anterior space has two small openings in its wall behind the roots of the glosso-pharyngeal nerves, which communicate with a pouch-like prolongation of the arachnoid beneath the flocculus. They communicate also with a still larger space formed by the loose disposition of the arachnoid around the spinal cord, the *spinal sub-arachnoid space.* The whole of these spaces, with the lesser spaces between the convolutions of the hemispheres, constitute one large and continuous cavity which is filled with a limpid serous secretion, the *sub-arachnoid* or *cerebro-spinal fluid,** a fluid which is necessary for the regulation of pressure, and protection of the cerebro-spinal mass. The quantity of the cerebro-spinal fluid is determined by the relative size of the cerebro-spinal axis and that of the containing cavity, and is consequently variable. It is smaller in youth than in old age, and in the adult has been estimated at about two ounces. The arachnoid is connected to the pia mater by a delicate areolar tissue, which in the sub-arachnoid space is loose and filamentous. The serous secretion of the sub-dural space is very small in quantity as compared with the sub-arachnoid fluid.

The arachnoid does not enter into the ventricles of the brain, as imagined by Bichat, but is reflected inwards upon the venæ Galeni for a short distance only, and returns upon those vessels to the dura mater of the tentorium. It surrounds the nerves as they originate from the brain, and forms a sheath around them to their point of exit from the skull.

Vessels of considerable size, but few in number, and branches of cranial **nerves**, are found in the arachnoid.

Structure.—The arachnoid consists of interlacing bundles of fine fibrous tissue, the interstices of which are occupied by spread-out cells.

The **pia mater** is an areolo-vascular membrane composed of innumerable vessels held together by fine bundles of connective tissue. It invests the whole surface of the brain, dipping into the sulci between the convolutions, and forming a fold in its interior called *velum interpositum.* It also forms folds in other situations, as in the third and fourth ventricles, and in the longitudinal fissures of the spinal cord.

This membrane differs in structure in different parts of the cerebro-spinal axis. Thus, on the surface of the cerebrum, in contact with the soft grey matter of the brain, it is extremely vascular, forming remarkable loops of anastomosis in the interspaces of the convolutions, and distributing multitudes of minute straight vessels to the grey substance. In the substantia perforata, again,

* The presence of a serous fluid beneath the arachnoid has given rise to the conjecture that a sub-arachnoid serous membrane may exist in that situation. Such a supposition is quite unnecessary to explain the production of the secretion, since the pia mater is fully adequate to the function.

and locus perforatus, it gives off tufts of small arteries, which pierce the white matter to reach the grey substance in the interior. But upon the crura cerebri, pons Varolii, and spinal cord, its vascular character seems almost lost. It has become a *dense fibrous membrane*, difficult to tear off, and forming the proper sheath of the spinal cord.

The pia mater is the nutrient membrane of the brain, and derives its blood from the internal carotid and vertebral arteries. Lymphatics have also been described as entering into its structure.

Its **nerves** are the minute filaments of the sympathetic, and filaments from the sensory cranial nerves; they accompany the branches of the arteries.

MEMBRANES OF THE SPINAL CORD.

The **dura mater spinalis** is a cylindrical sheath of fibrous membrane, identical in structure with the dura mater of the skull, and continuous with that membrane. At the margin of the occipital foramen it is closely adherent to the bone; by its anterior surface it is attached to the posterior common ligament, and below, by means of its pointed extremity, to the coccyx. In the rest of its extent it is comparatively free, being connected, by a loose areolar tissue, to the walls of the spinal canal. In this areolar tissue there exists a quantity of reddish, oily, adipose substance, somewhat analogous to the marrow of long bones. On either side and below, the dura mater forms a sheath for each of the spinal nerves, to which it is closely adherent. Upon its inner surface it is smooth, and on its sides may be seen double openings for the two roots of each of the spinal nerves.

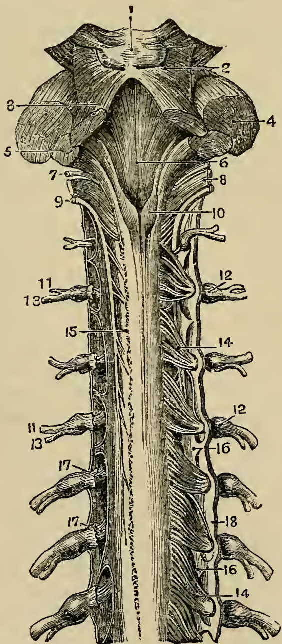


FIG. 291.—Fourth ventricle and upper part of spinal cord and membranes. The posterior roots of the nerves are removed on the left side. 1. Corpora quadrigemina. 2. Fillet of the olivary body. 3. Processus e cerebello ad testes. 4. Processus e cerebello ad pontem. 5. Processus e cerebello ad medullam. 6. Floor of fourth ventricle. 7. Glosso-pharyngeal nerve. 8. Pneumogastric nerve. 9. Spinal accessory nerve. 10. Posterior pyramids of medulla. 11, 11. Anterior divisions of spinal nerves. 12, 12. Ganglia of nerves. 13, 13. Posterior divisions of spinal nerves. 14, 14. Posterior roots of spinal nerves. 15. Line of origin of posterior roots of left side. 16, 16. Ligamentum denticulatum. 17, 17. Anterior root of spinal nerves. 18. Dura mater.

The **arachnoid** is a continuation of the serous membrane of the brain. It encloses the cord very loosely, being connected to it only by long slender filaments of areolar tissue, and by a longitudinal lamella which is attached to the posterior aspect of the cord. The areolar tissue is most abundant in the cervical region, and diminishes in quantity from above downwards; and the longitudinal lamella is complete only in the dorsal region. The arachnoid passes off from the cord on either side with the spinal nerves, to which it forms a sheath. A connection exists in several places between the arachnoid and dura mater. The space between the arachnoid and the spinal cord is identical with that already described as existing between the same parts in the brain, the *sub-arachnoid space.* It is occupied by a serous fluid, sufficient in quantity to expand the arachnoid, and fill completely the cavity of the dura mater. The *sub-arachnoid* or *cerebro-spinal fluid* keeps up a constant and gentle pressure on the entire surface of the brain and spinal cord, and yields with the greatest facility to the various movements of the cord, giving to those delicate structures the advantage of the principles so usefully applied by Dr. Arnott in the water bed.

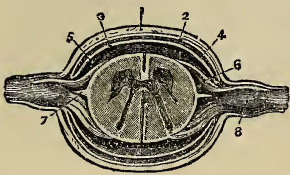


FIG. 292.—Transverse section of the spinal cord and its membranes. 1. Dura mater. 2. Inner lining of dura mater. 3. Arachnoid. 4. Sub-dural space. 5. Sub-arachnoid space. 6. Anterior root of nerve. 7. Ligamentum denticulatum. 8. Ganglion on posterior root of nerve.

The **pia mater** is the immediate investment of the cord; and, like the other membranes, is continuous with that of the brain. It is not, however, like the pia mater cerebri, a vascular membrane; but is dense and fibrous in structure, and contains but few vessels. It invests the cord closely, and sends a duplicature into the anterior median fissure, and another, extremely delicate, into the posterior median fissure. It forms a sheath for each of the fasciculi of the nerves, and for the nerves themselves; and, inferiorly, at the conical termination of the cord, is prolonged downwards as a slender ligament (*filum terminale*), which descends through the centre of the cauda equina, and is attached to the dura mater lining the canal of the coccyx. This attachment is a rudiment of the original extension of the spinal cord into the canal of the sacrum and coccyx. The pia mater has, distributed to it, a number of nervous plexuses.

The **ligamentum denticulatum** (*ligamentum dentatum*) is a thin process of pia mater sent off from each side of the cord throughout its entire length, and separating the anterior from the posterior roots of the spinal nerves. At its inner edge it is attached to the lateral aspect of the cord, and at its outer edge forms numerous saw-like processes or denticulations, the points of which are connected with the inner surface of the dura mater. The number of serrations on each side is about twenty, the first being situated on a level with the occipital foramen, and having the vertebral artery and hypoglossal

nerve passing in front and the spinal accessory nerve behind it, and the last opposite the first or second lumbar vertebra. Below this point the ligamentum denticulation is lost in the filum terminale of the pia mater. The denticulations do not pierce the arachnoid, but are covered by funnel-like prolongations of that membrane. The use of this membrane is to maintain the position of the spinal cord in the midst of the fluid by which it is surrounded.

CRANIAL NERVES.

The PAIRS of cranial nerves are *nine* or *twelve* in number, according as the arrangement of Willis or Soemmering is adopted; the former has been generally used in this country, but the latter is universally employed on the Continent. Willis numbered the pairs of nerves in correspondence with the openings in the base of the cranium, and included amongst them, as the tenth pair, the suboccipital or first cervical nerve, now considered as a spinal nerve. Soemmering treats the facial and the auditory nerve as separate pairs, under the name of seventh and eighth; the glosso-pharyngeal as the ninth pair; the pneumogastric the tenth; the spinal accessory the eleventh; and the hypoglossal the twelfth. They may be arranged in a tabular form, as follows:—

	1st. Olfactory.	4th. Pathetici (trochleares).	
	2d. Optic.	5th. Trifacial (trigemini).	
	3d. Motores oculorum.	6th. Abducentes.	
7th.	Facial (portio dura).	7th.	Soemmering.
	Auditory (portio mollis).	8th.	"
8th.	Glosso-pharyngeal.	9th.	"
	Pneumogastric (vagus, par vagum).	10th.	"
	Spinal accessory.	11th.	"
9th.	Hypoglossal (lingual).	12th.	"

Functionally or physiologically the cranial nerves admit of division into three groups—namely, nerves of special sense, nerves of motion, and compound nerves, that is, nerves which contain fibres both of sensation and motion. The nerves belonging to these groups are the following:—

Special sense . .	1st.	Olfactory.
	2d.	Optic.
	7th.	Auditory.
Motion	3d.	Motores oculorum.
	4th.	Pathetici.
	6th.	Abducentes.
	7th.	Facial.
	9th.	Hypoglossal.
Compound . . .	5th.	Trifacial.
	8th.	Glosso-pharyngeal.
	"	Pneumogastric.
	"	Spinal accessory.

√

FIRST PAIR.—OLFACTORY.

The olfactory tract is more truly a lobe or offshoot of the brain than a cranial nerve; it *arises* by three roots; an *inner* or *short root* from the inner and posterior part of the anterior lobe close to the substantia perforata; a *middle root* from a papilla of grey matter (caruncula mamillaris), embedded in the anterior lobe, and an *external* or *long root*, which may be traced as a white streak along the fissure of Sylvius into the middle lobe. The internal root is believed

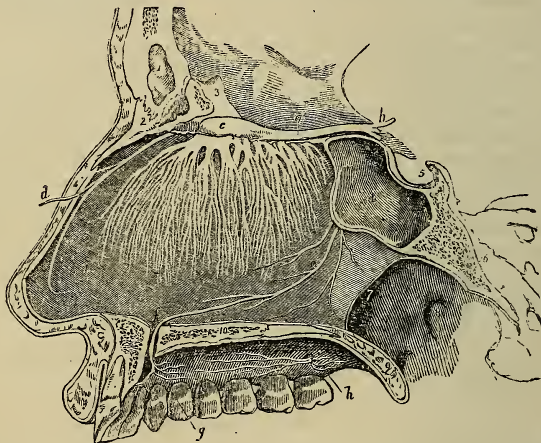


FIG. 293.—Olfactory nerves, with their distribution on the septum nasi. The nares have been divided by a longitudinal section made immediately to the left of the septum, the right naris being preserved entire. 1. Frontal sinus. 2. Nasal bone. 3. Crista galli process of ethmoid bone. 4. Sphenoidal sinus of left side. 5. Sella turcica. 6. Basilar process of sphenoid and occipital bone. 7. Posterior opening of the right naris. 8. Opening of the Eustachian tube in the upper part of the pharynx. 9. Soft palate divided through its middle. 10. Cut surface of the hard palate. *a.* Olfactory tract. *b.* Its three roots of origin. *c.* Its bulb, from which the filaments are seen to proceed which spread out in the substance of the pituitary membrane. *d.* Nasal branch of the ophthalmic nerve, dividing into its external and internal branch. *e.* Naso-palatine nerve, a branch from the spheno-palatine ganglion, distributing twigs to the mucous membrane of the septum nasi in its course to (*f*) the anterior palatine foramen. *g.* Branches of the naso-palatine nerve to the palate. *h.* Anterior and posterior palatine nerves. *i.* Septum nasi.

to be connected with the anterior part of the gyrus fornicatus, the middle root with the corpus striatum, and the external with a nucleus situated in the temporo-sphenoidal lobe, in front of the pes hippocampi. The nervous cord formed by the union of the three roots is soft in texture, prismoid in shape, and embedded in the olfactory sulcus on the under surface of each anterior lobe of the brain, lying between the pia mater and arachnoid. As it passes forward it in-

creases in breadth and swells at its extremity into an oblong mass of grey and white substance, the *olfactory bulb*, which rests on the cribriform plate of the ethmoid bone. From the under surface of the olfactory bulb are given off the nerves which pass through the cribriform foramina, and supply the mucous membrane of the nares; they are arranged into three groups: an inner group, reddish in colour and soft, which spread out upon the septum narium; an outer group, whiter and more firm, which descend through bony canals in the outer wall of the nares, and are distributed on the superior and middle turbinated bones; and a middle group, which supply the mucous membrane of the roof of the nasal fossæ. Each nerve is enclosed in a tabular prolongation of the dura mater and pia mater. The nerves are gelatinous in their character, are devoid of medullary sheath, and form frequent anastomoses with each other.

SECOND PAIR.—OPTIC.

This nerve consists of three parts: the *optic tract*, the *optic chiasma*, and the *nerve* proper. The first portion *arises* from the corpora geniculata on the posterior and inferior aspect of the thalamus opticus, from the thalamus itself, and from the nates. Proceeding from this origin it winds around the crus cerebri as a flattened band, and joins with its fellow in front of the tuber cinereum to form the *optic commissure* (chiasma). The optic tract is united with the crus cerebri and tuber cinereum, and is covered in by the pia mater; the commissure is also connected with the tuber cinereum, from which it receives fibres, and the nerve beyond the commissure diverges from its fellow, becomes rounded in form, and is enclosed in a sheath derived from the arachnoid. In passing through the optic foramen the optic nerve receives a sheath from the dura mater, which splits at this point into two layers: one, which becomes the periosteum of the orbit; the other, the one in question, which forms a sheath for the nerve, and is lost in the sclerotic coat of the eyeball. After a short course within the orbit the optic nerve pierces the sclerotic and choroid coats, and expands into the nervous membrane of the eyeball, the retina. Near the globe the nerve is pierced by a small artery, arteria centralis retinæ, which runs through the central axis of the nerve and reaches the inner layers of the retina, to which it distributes branches.

The **optic commissure** lies in a groove in front of the olivary body of the sphenoid bone; is bounded by the lamina cinerea in front, by the substantia perforata at each side, and by the tuber cinereum behind. Within the commissure the innermost fibres of each optic nerve cross each other to pass to the eye of the opposite side; the outer fibres continue their course uninterruptedly to the eye of the corresponding side. Some fibres pass in an arched direction from one nerve to the other behind, and others, taking a similar course in front, connect the two retinæ. The fibres which form the outer part of the tract and nerve, and pass uninterruptedly to the

eye of the same side, are much more numerous than the inner ones which cross. The neurilemma of the commissure, as well as that of the nerves, is formed by the pia mater.

THIRD PAIR.—MOTORES OCULORUM.

The motor oculi, a nerve of moderate size, *arises* from the inner side of the crus cerebri, close to the pons Varolii, and passes forward between the posterior cerebral and superior cerebellar arteries. Its deep origin has been traced to the locus niger, and to a grey nucleus beneath the floor of the aqueduct of Sylvius and corpora quadrigemina. It pierces the dura mater immediately in front of the posterior clinoid process; descends obliquely in the external wall of the cavernous sinus; and divides into two branches which enter the orbit through the sphenoidal fissure and between the two heads of the external rectus muscle. The *superior* branch ascends, and supplies the superior rectus and levator palpebræ. The *inferior* sends a branch beneath the optic nerve to the internal rectus, another to the inferior rectus, and a long branch to the inferior oblique muscle. From the latter a short thick branch is given to the ophthalmic ganglion, forming its inferior root. The branches of the third nerve enter the muscles on their ocular side.

In the cavernous sinus it receives one or two filaments from the carotid plexus, and one from the ophthalmic nerve.

FOURTH PAIR.—PATHETICI (trochlearis).

The fourth is the smallest cerebral nerve; it *arises* from the valve of Vieussens close to the testis, and winding around the crus cerebri to the extremity of the petrous portion of the temporal bone, pierces the dura mater below the third nerve, and passes forward in the outer wall of the cavernous sinus to the sphenoidal fissure. In its course in the outer wall of the sinus it is situated at first below the motor oculi, but afterwards ascends and becomes the highest of the nerves entering the orbit by the sphenoidal fissure. On entering the orbit the nerve crosses the levator palpebræ muscle near its origin, and is distributed on the orbital surface of the superior oblique or trochlearis muscle; hence its synonym *trochlearis.*

The fibres of origin of the two nerves communicate with each other, forming a kind of commissure, while those of the deep origin of the nerve may be traced in two fasciculi to a grey nucleus in the floor of the aqueduct of Sylvius in front, and to a similar nucleus in the floor of the fourth ventricle behind.

Branches.—While in the cavernous sinus the fourth nerve gives off a recurrent branch, and sends a branch of communication to the ophthalmic nerve; the *recurrent branch*, consisting of sympathetic filaments derived from the carotid plexus, passes backwards between the layers of the tentorium, and divides into two or three filaments, which are distributed to the lining membrane of the

lateral sinus. This recurrent nerve is sometimes a branch of the ophthalmic, and occasionally proceeds directly from the carotid plexus. Sometimes the communication with the ophthalmic takes place in the orbit, in which case the lachrymal nerve has the appearance of arising by two roots.

FIFTH PAIR.—TRIFACIAL (trigeminus).

The fifth nerve, the great sensitive nerve of the head and face, and the largest cranial nerve, is analogous to the spinal nerves in its origin by two roots from the anterior and posterior columns of the spinal cord, and in the existence of a ganglion on the posterior root. It *arises*, or rather makes its appearance at the surface of the brain, on the anterior part of the lateral and constricted portion of the pons Varolii, and consists of a large and small fasciculus, separated by a narrow interspace, the larger fasciculus being the posterior or sensory root; the smaller one, the anterior or motor root. The sensory root is composed of from seventy to a hundred filaments each enclosed in a sheath of pia mater, and the entire bundle is bound together into a single nerve and connected with the motor root by a sheath of arachnoid membrane. The nerve then passes through an oval opening in the border of the tentorium, near the extremity of the petrous bone, and spreads out into a large semilunar ganglion, the Gasserian. If the ganglion be turned over, it will be seen that the anterior root lies against its under surface without having any connection with it, and may be followed onwards to the inferior maxillary nerve. The Gasserian ganglion divides into three branches—ophthalmic, superior maxillary, and inferior maxillary.

Following the nerve to its *deep origin*, the *posterior root* may be traced between the transverse layers of the pons Varolii, behind the olivary and restiform bodies and fasciculus teres to the grey substance of the floor of the fourth ventricle; the *anterior root* being lost among the longitudinal fibres prolonged upwards from the anterior pyramid, or, according to Stilling, also pursuing its course to the grey substance of the floor of the fourth ventricle.

The **OPHTHALMIC NERVE** is the nerve of sensation of the eyeball, lachrymal gland, mucous membrane of the eye and nose, integument of the forehead and nose, and muscles of the eyebrow and forehead. It arises from the upper part of the Gasserian ganglion by a short trunk, about three-quarters of an inch in length; passes forwards in the outer wall of the cavernous sinus, lying externally to the other nerves, and divides into three branches. Previously to its division it receives several filaments from the carotid plexus, and gives off a small *recurrent nerve*, which passes backwards with the recurrent branch of the fourth nerve between the two layers of the tentorium to the lining membrane of the lateral sinus.

The **branches** of the ophthalmic nerve are the—

Frontal, Lachrymal, Nasal.

The **frontal nerve** enters the orbit immediately to the outer side of the fourth nerve, and passing forwards, for some distance, upon the levator palpebræ muscle, divides into a supra-orbital and supra-trochlear branch.

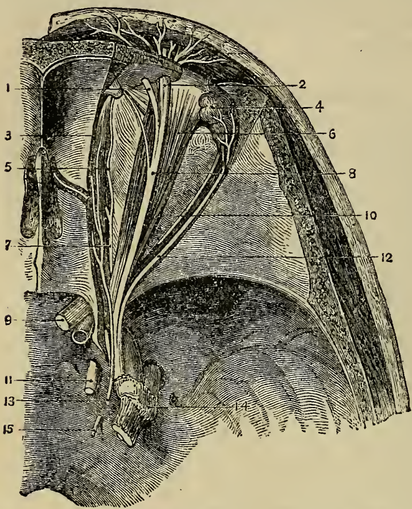


FIG. 294.—Superficial dissection of the nerves of the orbit. 1. Supra-trochlear nerve. 2. Supra-orbital nerve. 3. Obliquus superior. 4. Lachrymal gland. 5. Infra-trochlear nerve. 6. Levator palpebræ superioris. 7. Nasal nerve (fifth). 8. Frontal nerve (fifth). 9. Optic nerve. 10. Rectus superior. 11. Third nerve. 12. Lachrymal nerve. 13. Fourth nerve. 14. Gasserian ganglion of fifth. 15. Sixth nerve.

The *supra-orbital* branch, the proper continuation of the nerve, passes out of the orbit through the supra-orbital notch, in company with the supra-orbital artery, and after giving filaments to the upper eyelid, muscles of the forehead and pericranium, divides into two cutaneous branches, internal and external. The *internal branch* pierces the occipito-frontalis and is distributed to the integument as far as the summit of the head. The *external branch* of larger size communicates with the facial nerve, and piercing the occipito-frontalis supplies the integument as far back as the occiput.

The *supra - trochlear* branch passes inwards to the angle of the orbit, above the pulley of the superior oblique muscle, and is distributed to the inner angle of the eye, root of the nose, and integument of the middle line of the forehead. It communicates with the infra-trochlear branch of the nasal nerve.

The **lachrymal nerve**, the smallest of the three branches of the ophthalmic, enters the orbit on the outer side of the frontal, but enclosed in a separate sheath of dura mater; and passes forward, above the upper border of the external rectus muscle, and in company with the lachrymal artery to the lachrymal gland, where it divides into two branches, superior and inferior. The *superior branch* passes over the gland which it supplies on the upper surface. The *inferior branch* supplies the under surface of the gland, upper lid, and outer angle of the eye. It gives off a branch which passes downwards to join the orbital branch of the superior maxillary, and from the connection between these two nerves, temporo-malar filaments are derived which pass through foramina in the malar bone

to be distributed to the outer part of the face and the temple, communicating with branches of the facial and auriculo-temporal nerves.

The lachrymal nerve sometimes receives the branch of the fourth nerve destined for the ophthalmic, and appears to arise by two roots.

The **nasal nerve** enters the orbit between the two heads of the external rectus and between the two branches of the third nerve.

Fig. 295.—Diagram showing the fifth pair of nerves with its branches. 1. Origin of the nerve by two roots. 2. The nerve escaping from the pons Varolii. 3. Gasserian ganglion. 4. Ophthalmic nerve. 5. Frontal nerve giving off the supratrochlear branch. 6. Lachrymal nerve. 7. Nasal nerve passing at 8 through the anterior ethmoidal foramen, and giving off the infra-trochlear branch. 9. Superior root of the ophthalmic ganglion given off from nasal nerve. 10. Inferior or motor root, derived from third nerve; the ganglion gives off the ciliary nerves from its anterior aspect. 11. Superior maxillary nerve. 12. Orbital branch. 13. Spheno-palatine nerves communicating with Meckel's ganglion; the three branches from the lower part of the ganglion are the palatine nerves. 14, 14. Superior dental nerves, posterior, middle, and anterior. 15. Infra-orbital branches. 16. Inferior maxillary nerve. 17. Its anterior or muscular trunk. 18. The posterior trunk; the two divisions are separated by an arrow. 19. Gustatory nerve. 20. Chorda tympani joining it at an acute angle. 21. Submaxillary ganglion. 22. Inferior dental nerve. 23. Mylo-hyoid branch. 24. Auriculo-temporal nerve, dividing behind the articulation of the lower jaw, to reunite and form a single trunk. 25. Its branch of communication with the facial nerve. 26. Continuation of its trunk to the temple.

It crosses the optic nerve in company with the ophthalmic artery, and, passing over the internal rectus, enters the anterior ethmoidal foramen, by which it is conducted to the cribriform plate of the ethmoid bone. It then passes through the slit-like opening by the side of the crista galli, and descends into the nose, where it divides into an internal and external branch. The *internal branch* is dis-

tributed to the mucous membrane ; the *external branch*, passing outwards between the nasal bone and cartilage, supplies the integument of the exterior of the nose as far as its tip.

The **branches** of the nasal nerve are—*ganglionic*, *ciliary*, and *infra-trochlear*.

The **ganglionic branch**, about half an inch in length and of small size, enters the upper angle of the ophthalmic ganglion, and constitutes its superior or long root. It is often joined by the sympathetic root of the ganglion derived from the cavernous plexus.

The **long ciliary branches** are two or three filaments given off from the nerve as it crosses the optic nerve. They pierce the

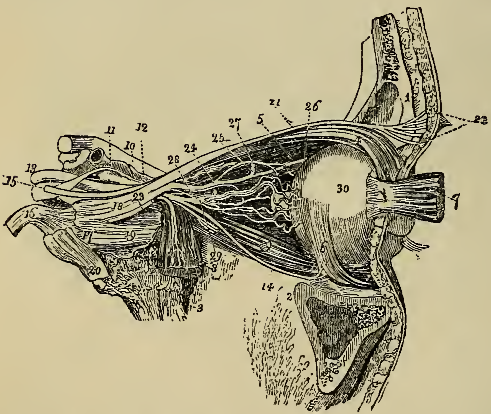


FIG. 296.—Nerves of the orbit seen from the outer side. 1. Section of frontal bone. 2. Superior maxillary bone. 3. Part of sphenoid bone. 4. Levator palpebræ and superior rectus muscles. 5. Superior oblique muscle. 6. Inferior oblique. 7. Ocular half of the external rectus drawn forwards. 8. Orbital half of the external rectus turned downwards. On this muscle the sixth nerve is seen dividing into branches. 9. Inferior rectus. 10. Optic nerve. 11. Internal carotid artery emerging from the cavernous sinus. 12. Ophthalmic artery. 13. Third nerve. 14. Branch of the third nerve to the inferior oblique muscle. Between this and the sixth nerve (8) is seen the branch which supplies the inferior rectus; its branch to the ophthalmic ganglion is seen proceeding from the upper side of the trunk of the nerve, at the bottom of the orbit. 15. Fourth nerve. 16. Trunk of the fifth nerve. 17. Gasserian ganglion. 18. Ophthalmic nerve. 19. Superior maxillary nerve. 20. Inferior maxillary nerve. 21. Frontal nerve. 22. Its divisions into branches to supply the integument of the forehead. 23. Lachrymal nerve. 24. Nasal nerve; the small nerve seen in the bifurcation of the nasal and frontal, is one of the branches of the upper division of the third nerve. 25. Nasal nerve passing over the internal rectus muscle to the anterior ethmoidal foramen. 26. Infra-trochlear nerve. 27. A long ciliary branch of the nasal; another long ciliary branch is seen proceeding from the lower aspect of the nerve. 28. Long root of the ophthalmic ganglion, proceeding from the nasal nerve, and receiving the sympathetic root which joins it at an acute angle. 29. Ophthalmic ganglion, giving off from its forepart the short ciliary nerves. 30. Globe of the eye.

sclerotic coat near the short ciliary nerves, and passing through the globe of the eye between the sclerotic and choroid, are distributed to the iris.

The **infra-trochlear branch** is given off close to the anterior ethmoidal foramen. It passes forward along the upper border of the internal rectus to the inner angle of the eye, where it communicates

with the supra-trochlear nerve, and is distributed to the lachrymal sac and inner angle of the orbit.

The **SUPERIOR MAXILLARY NERVE**, larger than the preceding, is the nerve of sensation of the teeth of the upper jaw, the hard and soft palate, tonsils, antrum maxillare, and muscles and integument of the lower eyelid, cheek, and upper lip. Proceeding from the middle of the Gasserian ganglion, it passes forward through the foramen rotundum, crosses the spheno-maxillary fossa, and enters the canal in the floor of the orbit, along which it runs to the infra-orbital foramen. Emerging on the face, beneath the levator labii superioris muscle, it becomes the *infra-orbital nerve*, and divides into palpebral, nasal, and labial branches, which form a plexus with the facial nerve.

The **branches** of the superior maxillary nerve are divisible into three groups: namely, those given off in the spheno-maxillary fossa; those given off in the infra-orbital canal; and those given off on the face. They may be thus arranged :—

Spheno-maxillary fossa . .	Orbital, or temporo-malar, Spheno-palatine, Posterior dental.
Infra-orbital canal . . .	Middle dental, Anterior dental.
On the face	Muscular, Cutaneous.

The **orbital branch** enters the orbit through the spheno-maxillary fissure, and divides into two branches, temporal and malar; the *temporal branch* ascends along the outer wall of the orbit, and after receiving a branch from the lachrymal nerve, passes through a canal in the malar bone, and enters the temporal fossa; it then pierces the temporal muscle and fascia, and is distributed to the integument of the temple and side of the forehead, communicating with the facial and auriculo-temporal nerves. In the temporal fossa it communicates with the deep temporal nerves. The *malar*, or inferior branch (subcutaneus malæ) takes its course along the lower angle of the outer wall of the orbit, and emerges on the cheek through an opening in the malar bone, passing between the fibres of the orbicularis palpebrarum muscle. It communicates with branches of the infra-orbital and facial nerve.

The **spheno-palatine branches**, two in number, pass downwards to the spheno-palatine or Meckel's ganglion.

The **posterior dental branches**, two in number, pass downwards upon the tuberosity of the superior maxillary bone, where *one* enters a canal in the bone, and is distributed to the molar teeth and lining membrane of the antrum, and communicates with the anterior dental nerve; while the *other*, lying externally to the bone, is distributed to the gums and buccinator muscle.

The **middle** and **anterior dental branches** descend to the corresponding teeth and gums; the former beneath the lining membrane

of the antrum, the latter through distinct canals in the walls of the bone. Previously to their distribution, the dental nerves form a plexus (superior maxillary plexus) in the outer wall of the superior maxillary bone immediately above the alveolus. From this plexus filaments are given off which supply the pulps of the teeth, gums, mucous membrane of the floor of the nares, and palate. Some gangliform bodies have been described in connection with this plexus, one being placed over the canine, another over the second molar tooth; the former has been named the *ganglion of Bochdalek.*

The **muscular** and **cutaneous branches** are the terminating filaments of the nerve; they supply the muscles, integument, and

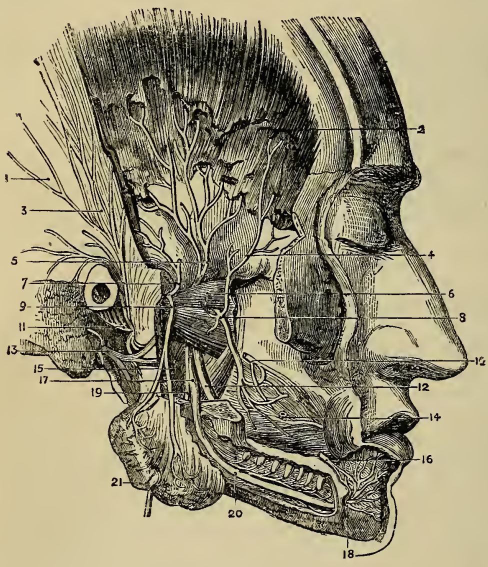


Fig. 297. — Pterygo-maxillary region and fifth nerve. 1. Temporal fascia. 2. Temporal muscle. 3. Temporal branches of auriculo-temporal nerve. 4. Deep temporal branch of buccinator nerve. 5. Deep temporal nerve. 6. External pterygoid muscle. 7. Deep temporal branch of masseteric nerve (inconstant). 8. Buccal nerve. 9. Masseteric nerve. 10. Buccal branch of seventh. 11. Auriculo-temporal nerve. 12. Gustatory nerve. 13. Facial nerve (seventh) at stylo-mastoid foramen. 14. Buccinator muscle. 15. Internal pterygoid. 16. Supramaxillary branch of seventh. 17. Inferior dental nerve. 18. Its mental branches. 19. Its mylo-hyoid branch. 20. Inferior dental canal opened. 21. Masseter (turned down).

mucous membrane of the lower eyelid, cheek, nose, and upper lip, and form a plexus by their communications with the facial nerve.

The **INFERIOR MAXILLARY NERVE** is a nerve both of sensation and motion, and is distributed to the teeth and gums of the lower jaw, to the tongue, which it supplies with the sense of taste, to the integument of the temple, external ear, lower part of the face and lower lip, and to the muscles of mastication. It proceeds from the inferior angle of the Gasserian ganglion, is the largest of the three divisions of the fifth nerve, and is increased in size by the anterior or motor root, which, passing behind the ganglion, unites with the inferior maxillary as it escapes through the

foramen ovale. Emerging at the foramen ovale the nerve divides into two trunks, anterior and posterior, separated from each other by the external pterygoid muscle; the anterior division is almost entirely motor, but its buccal branch is believed to be in chief part sensory; the posterior division is sensory, but the mylo-hyoid branch of the inferior dental is motor.

The **anterior division**, into which may be traced nearly the whole of the motor root, immediately separates into five or six branches, distributed to the muscles of the temporo-maxillary region; they are—masseteric, temporal, buccal, internal pterygoid, and external pterygoid.

The **masseteric branch** passing over the external pterygoid muscle, and behind the tendon of the temporal, crosses the sigmoid notch with the masseteric artery to the masseter muscle. It sends a small branch to the temporal muscle, and a filament to the temporo-maxillary articulation.

The **deep temporal branches**, two in number, **anterior** and **posterior**, pass between the upper border of the external pterygoid muscle and the temporal bone to the temporal muscle. Two or three filaments from these nerves pierce the temporal fascia, and communicate with the lachrymal, subcutaneus malæ, superficial temporal and facial nerve.

The **buccal branch** is of large size, and pierces the lower fibres of the external pterygoid muscle at its anterior part; it runs downwards and forwards in close contact with the inner surface of the tendon of the temporal muscle and accompanied by the buccal branch of the internal maxillary artery. It sends a branch to the external pterygoid muscle, and is distributed to the buccinator and mucous membrane and integument of the cheek, communicating with the facial nerve.

The **internal pterygoid branch** is a long and slender nerve which passes inwards to the internal pterygoid muscle, and enters it on its deep surface. This nerve is remarkable for its connection with the otic ganglion, to which it is closely adherent.

The **external pterygoid branch** is commonly derived from the buccal nerve.

The **posterior division** of the inferior maxillary nerve splits into three branches—

Auriculo-temporal, Inferior dental, Gustatory.

The **AURICULO-TEMPORAL NERVE** originates by two roots, between which the middle meningeal artery takes its course, and passes directly backwards behind the articulation of the lower jaw. It then ascends between that articulation and the meatus auris, and, escaping from beneath the parotid gland, divides into two temporal branches. While behind the temporo-maxillary articulation, it forms a kind of plexus, and sends off several branches.

Its **branches** are—a small branch to the temporo-maxillary articulation; two or three to the parotid gland; two to the meatus auris, which enter the canal between the fibro-cartilage and processus auditorius; two auricular branches to the pinna; a communicating branch to the otic ganglion; two communicating branches to the facial nerve, and the temporal branches.

The **auricular branches, superior** and **inferior,** are distributed to the pinna above and below the meatus. The inferior branch communicates with the sympathetic.

The branches which communicate with the facial nerve embrace the external carotid artery in their course.

The **temporal** branches are anterior and posterior: the **anterior** accompanies the anterior temporal artery, and supplies the integument of the temporal region, communicating with branches of the facial, supra-orbital, subcutaneus malæ, and lachrymal nerve; the **posterior** is distributed to the upper part of the pinna, attrahens auriculam muscle, and integument of the posterior part of the temple.

The **INFERIOR DENTAL NERVE,** the largest of the three branches of the posterior division of the inferior maxillary, passes downwards with the inferior dental artery, at first between the two pterygoid muscles, then between the internal lateral ligament and ramus of the lower jaw, to the dental foramen, next it runs along the canal in the inferior maxillary bone, distributing branches (inferior maxillary plexus) to the teeth and gums, and divides into two terminal branches, incisive and mental.

The **branches** of the inferior dental nerve, besides those given to the teeth, are the mylo-hyoid and the two terminal branches.

The **mylo-hyoid branch** leaves the nerve just as it is about to enter the dental foramen; it then pierces the insertion of the internal lateral ligament, and descends along a groove in the bone to the inferior surface of the mylo-hyoid muscle, to which, and to the anterior belly of the digastricus, it is distributed.

The **incisive branch** is continued forward to the symphysis of the jaw, to supply the incisor teeth.

The **mental** or **labial branch** emerges from the jaw at the mental foramen, beneath the depressor anguli oris, and divides into branches which supply the muscles and integument of the lower lip and chin, and communicate with the facial nerve.

The **GUSTATORY NERVE** (lingual branch of the fifth) descends between the two pterygoid muscles, and makes a gentle curve forwards to the side of the tongue, along which it takes its course to the tip. On the side of the tongue it is flattened, and gives off numerous branches, which are distributed to the mucous membrane and papillæ.

In the upper part of its course the gustatory nerve lies between the external pterygoid muscle and the pharynx, next between the two pterygoid muscles, then between the internal pterygoid and ramus of the jaw, crosses the upper border of the superior constrictor

of the pharynx, and runs between the stylo-glossus muscle and the submaxillary gland; lastly, it runs along the side of the tongue, resting against the hyo-glossus muscle and crossing the duct of the submaxillary gland, and is covered in by the mylo-hyoid muscle and mucous membrane.

The gustatory nerve, while between the pterygoid muscles, often receives a communicating branch from the inferior dental; lower down it is joined at an acute angle by the chorda tympani, a small nerve, which, arising from the facial in the aqueductus Fallopii, crosses the tympanum, and escapes from that cavity through the canal of Huguier at the inner end of the fissure of Glaser. Having joined the gustatory nerve, the chorda tympani is continued downwards in its sheath to the submaxillary ganglion and tongue.

One or two **branches** are given by the gustatory nerve to the submaxillary ganglion.

On the hyo-glossus muscle several **branches** of communication join with branches of the hypoglossal nerve, and others are sent to the sublingual gland, Wharton's duct, and mucous membrane of the mouth and gums.

SIXTH PAIR.—ABDUCENTES.

The abducens nerve, about half the size of the motor oculi, *arises* by several filaments from the upper constricted part of the anterior pyramid, and by a few fibres from the pons Varolii. Proceeding forwards from this origin, it lies parallel with the basilar artery, and, piercing the dura mater on the clivus Blumenbachii of the sphenoid bone, ascends between the two layers of that membrane to the cavernous sinus. It then runs forward on the inner wall of the sinus, below the level of the other nerves and resting against the internal carotid artery, to the sphenoidal fissure. Entering the orbit through the sphenoidal fissure it passes between the two heads of the external rectus, and is distributed to that muscle. At the sphenoidal fissure it lies upon the ophthalmic vein, from which it is separated by a lamina of dura mater; and in the cavernous sinus is joined by several filaments from the carotid plexus.

Mayo traced the deep origin of this nerve between the fasciculi of the anterior pyramid to the posterior part of the medulla oblongata; and it appears to arise from the grey substance of the fourth ventricle.

SEVENTH PAIR.

The seventh pair of nerves, of Willis, consists of two nervous cords which lie side by side on the posterior border of the crus cerebelli in the groove between the olivary and restiform bodies. The smaller and most internal of these, and at the same time the most dense in texture, is the facial nerve or portio dura. The

external nerve, which is soft and pulpy, and often grooved by contact with the preceding, is the auditory nerve or portio mollis.*

FACIAL NERVE; **portio dura**; **seventh pair** of Soemmering.—The facial nerve, the motor nerve of the face, *arises* from the upper part of the groove between the olivary and restiform bodies close to, and by a few fibres from the pons Varolii; its deep origin being traced through the restiform body to the side of the floor of the fourth ventricle. The nerve passes forward, resting on the crus cerebelli, and comes into relation with the auditory nerve, with which it enters the meatus auditorius internus, lying at first to the inner side of, and then upon that nerve. At the bottom of the meatus, the facial nerve enters the aqueductus Fallopii, and takes its course forwards to the hiatus Fallopii, in the anterior wall of the petrous bone, where it forms a gangliform swelling (**intumescentia gangliformis, geniculate ganglion**), and receives the petrosal branch of the Vidian nerve. It then curves backwards towards the tympanum, and descends in the inner wall of that cavity to the stylo-mastoid foramen. Emerging at the stylo-mastoid foramen, it passes forwards within the parotid gland, crossing the external carotid artery, to the ramus of the lower jaw, where it splits into two trunks, **temporo-facial** and **cervico-facial.** These trunks divide into numerous branches, which escape from the anterior border of the parotid gland, and are distributed in a radiated manner over the side of the face, from the temple to below the lower jaw; on the masseter muscle the branches communicate and form loops, and the whole arrangement over the side of the face has been termed **pes anserinus.**

In the meatus auditorius, the facial nerve communicates with the auditory nerve by one or two filaments; the intumescentia gangliformis receives the greater and lesser petrosal nerves, and sends a twig back to the auditory nerve; at the back of the tympanum, the nerve receives one or two twigs from the auricular branch of the pneumogastric; at its exit from the stylo-mastoid foramen it receives a twig from the glosso-pharyngeal, and in the parotid gland one or two large branches from the auriculo-temporal nerve. Besides these, the facial nerve has numerous peripheral communications, with the branches of the fifth nerve on the face, with the cervical nerves in the parotid gland and on the neck, and with the sympathetic.

The **branches** of the facial nerve are—

Within the aqueductus Fallopii	Tympanic, Chorda tympani.
After emerging at the stylo-mastoid foramen	Posterior auricular, Stylo-hyoid, Digastric.
On the face	Temporo-facial, Cervico-facial.

* A third nerve of small size, *portio intermedia* of Wrisberg, is brought into view by separating these two cords. The researches of Morganti render it probable that the portio intermedia is connected, at its origin in the restiform body, with the

The **tympanic branch** is a small filament given off by the facial while in the petrous bone, and distributed to the stapedius muscle.

The **chorda tympani** quits the facial immediately above the stylo-mastoid foramen, and ascends by a distinct canal to the upper

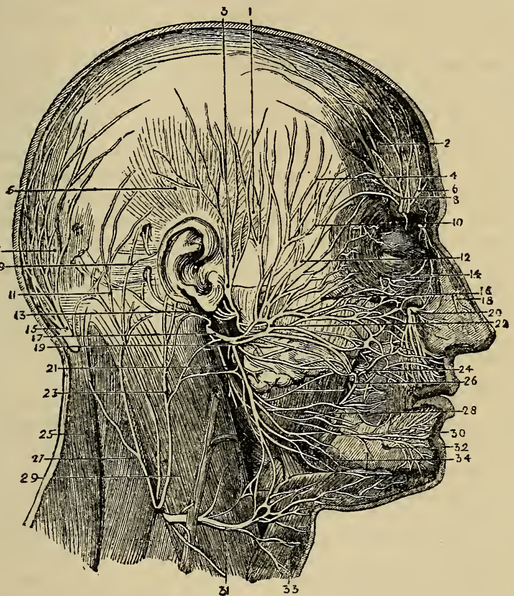


Fig. 298.—Nerves of the face and scalp. 1. Attrahens auriculam muscle. 2. Anterior belly of occipito-frontalis. 3. Auriculo-temporal nerve. 4. Temporal branches of facial nerve. 5. Attollens auriculam muscle. 6. Supra-trochlear nerve. 7. Posterior belly of occipito-frontalis. 8. Supra-orbital nerve. 9. Retrahens auriculam muscle. 10. Temporal branch of orbital nerve (superior maxillary). 11. Occipitalis minor nerve. 12. Malar branches of facial. 13. Posterior auricular. 14. Malar branch of temporo-malar. 15. Great occipital. 16. Infra-orbital branches of facial. 17. Facial. 18. Nasal branch of ophthalmic. 19. Cervico-facial division of facial. 20. Infra-orbital branch of fifth. 21. Branches of facial to digastric and stylo-hyoid. 22. Temporo-facial division of facial. 23. Great auricular. 24. Buccal branches of facial. 25. Trapezius muscle.

part of the posterior wall of the tympanum, where it enters that cavity through an opening situated between the base of the pyramid and the attachment of the membrana tympani, and becomes invested by mucous membrane. It then crosses the tympanum between the

auditory nerve; that it is the posterior or sensitive root of the facial; that the intumescentia gangliformis of the facial is the ganglion of this root; that it bestows the principal part of the sensitive function on the facial; and that the chorda tympani is partly derived from the intumescentia gangliformis.

handle of the malleus and long process of the incus to its anterior inferior angle, and escapes through an opening at the inner end of the fissure of Glaser (canal of Huguier), to join the gustatory nerve at an acute angle between the two pterygoid muscles. Enclosed in the sheath of the gustatory nerve, it descends to the submaxillary gland, where part of it ends in the submaxillary ganglion; the rest is continued onwards with the filaments of the gustatory, to be distributed to the tongue.

The **posterior auricular branch** ascends behind the ear, between the meatus and mastoid process, and divides into an anterior or auricular, and a posterior or occipital branch. The *auricular* branch receives a filament of communication from the auricular branch of the pneumogastric nerve, and distributes filaments to the retrahens auriculam muscle and pinna. The *occipital* branch communicates with the auricularis magnus and occipitalis minor, and is distributed to the occipital portion of the occipito-frontalis.

The **stylo-hyoid branch** is distributed to the stylo-hyoid muscle, and communicates with the sympathetic plexus of the external carotid artery.

The **digastric branch** supplies the posterior belly of the digastricus muscle, and communicates with the glosso-pharyngeal and pneumogastric nerve. This nerve and the preceding often arise from the facial by a common trunk.

The **TEMPORO-FACIAL DIVISION**, while in the parotid gland, sends a branch of communication along the carotid artery to the auriculo-temporal nerve, and divides into temporal, malar, and infra-orbital branches.

The **temporal branches** ascending upon the temporal region supply the attrahens auriculam, occipito-frontalis, and orbicularis palpebrarum; and communicate with the supra-orbital nerve and temporal branch of the superior maxillary.

The **malar branches** cross the malar bone to the outer angle of the eye, and supply the orbicularis palpebrarum, corrugator supercilii, and eyelids. They communicate with the subcutaneus malæ branch of the superior maxillary nerve, and with branches of the ophthalmic nerve in the eyelids.

The **infra-orbital branches** cross the masseter muscle, and are distributed to the buccinator, elevator muscles of the upper lip, and orbicularis oris. They communicate with the terminal branches of the infra-orbital nerve, infra-trochlear, and nasal nerve. Two or more of these branches are found by the side of Stenson's duct.

The **CERVICO-FACIAL DIVISION**, smaller than the temporo-facial, communicates in the parotid gland with the auricularis magnus nerve, and divides into branches which admit of arrangement into three sets; buccal, supra-maxillary, and infra-maxillary.

The **buccal branches** pass forward across the masseter muscle towards the mouth, and distribute branches to the orbicularis oris and buccinator. They communicate with branches of the temporo-facial, and with the buccal branch of the inferior maxillary nerve.

The **supra-maxillary branches** are destined to the muscles of the lower lip, and take their course along the body of the lower jaw. Beneath the depressor anguli oris, they have a plexiform communication with the inferior dental nerve.

The **infra-maxillary branches** (subcutanei colli) take their course below the lower jaw, pierce the deep cervical fascia, and are distributed to the platysma, communicating with the superficialis colli nerve.

AUDITORY NERVE; **portio mollis**; **eighth pair** of Soemmering.—The auditory nerve takes its origin in the lineæ transversæ of the floor of the fourth ventricle, and winds around the restiform body, from which it receives fibres, to the posterior border of the crus cerebelli. It then passes forward on the crus cerebelli in company with the facial nerve, which lies in a groove on its superior surface, enters the meatus auditorius internus, and at the bottom of the meatus divides into two branches, *cochlear* and *vestibular*. The distribution of these branches will be found described with the anatomy of the internal ear. The auditory nerve is soft and pulpy in texture, and receives in the meatus auditorius several filaments from the facial nerve.

EIGHTH NERVE.

Eighth pair of Willis; ninth, tenth, and eleventh pairs of Soemmering; consists of three nerves, glosso-pharyngeal, pneumogastric, and spinal accessory.

GLOSSO-PHARYNGEAL NERVE.—The glosso-pharyngeal nerve, as its name implies, is the nerve of sensation of the mucous membrane of the tongue and pharynx, but it also gives branches to some of the muscles of these organs. It *arises* by five or six filaments from the groove between the olivary and restiform bodies, and escapes from the skull at the innermost extremity of the jugular foramen through a distinct opening in the dura mater, lying anteriorly to the sheath of the pneumogastric and spinal accessory nerve, and internally to the jugular vein. It then passes forward between the jugular vein and internal carotid artery, and crosses the artery to reach the posterior border of the stylo-pharyngeus. Following the posterior border of this muscle for a short distance, it next passes across it and the middle constrictor and behind the hyoglossus muscle, to be distributed to the mucous membrane of the tongue, pharynx, and tonsil.

The deep origin of the nerve lies beneath the floor of the fourth ventricle, above the nucleus of the vagus and below that of the auditory nerve. While in the jugular fossa, it presents two gangliform swellings; one *superior*, the *jugular ganglion*, of small size, and involving only the posterior fibres of the nerve; the other *inferior*, nearly half an inch below the preceding, of larger size, and occupying the whole diameter of the nerve, the *petrous ganglion* or *ganglion of Andersch.*

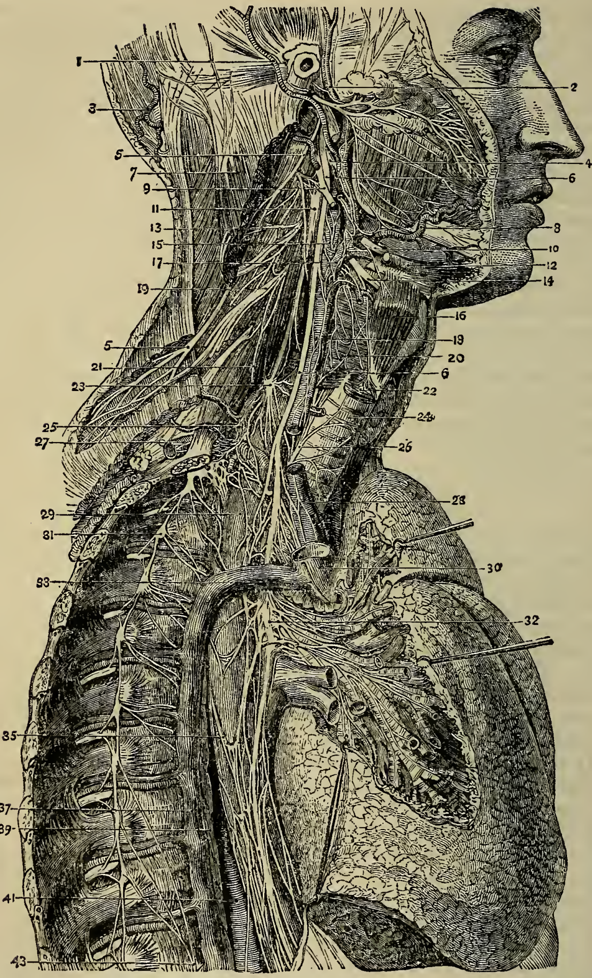


Fig. 299.—Distribution of the eighth nerve of the right side. 1. Posterior auricular artery. 2. Temporal artery. 3. Occipital artery. 4. Glosso-pharyngeal nerve. 5, 5. Spinal accessory nerve. 6, 6. Pneumogastric nerve. 7. Sterno-mastoid (cut). 8. Facial artery. 9. Hypoglossal nerve, with communication from second cervical nerve. 10. Lower end of ditto. 11. Superior cervical ganglion of sympathetic. 12. Digastricus. 13. Third cervical nerve. 14. Superior laryngeal nerve. 15. Internal carotid. 16. Thyro-hyoid muscle. 17. External carotid. 18. Common carotid. 19. Fourth cervical nerve. 20. Inferior constrictor of pharynx. 21. Phrenic nerve on scalenus anticus. 22. Crico-thyroid. 23. Middle cervical ganglion.

24. Trachea. 25. Thyroid axis. 26. Recurrent laryngeal nerve. 27. Subclavian artery. 28. Innominate artery. 29. Œsophagus. 30. Vena cava superior (cut). 31. Gangliated cord of sympathetic. 32. Posterior pulmonary plexus. 33. Phrenic nerve (cut). 35. Œsophageal plexus. 37. Vena azygos major. 39. Thoracic duct. 41. Thoracic aorta. 43. Great splanchnic nerve.

The **branches** of the glosso-pharyngeal nerve are branches of communication and branches of distribution.

The **branches of communication** proceed chiefly from the ganglion of Andersch; they are—one to join the auricular branch of the pneumogastric; one to the ganglion of the root of the pneumogastric; one to the superior cervical ganglion of the sympathetic; and one, which arises below the ganglion and pierces the posterior belly of the digastricus muscle, to join the facial nerve.

The **branches of distribution** are—

Tympanic,	Pharyngeal,
Carotid,	Tonsillitic,
Muscular,	Lingual.

The **tympanic branch** (Jacobson's nerve) proceeds from the ganglion of Andersch, or from the trunk of the nerve immediately above the ganglion; it enters a small bony canal in the jugular fossa (p. 83), and divides into six branches, which are distributed on the inner wall of the tympanum, and establish a plexiform communication (tympanic plexus) with the sympathetic and fifth pair of nerves. The *branches* of distribution supply the fenestra rotunda, fenestra ovalis, and Eustachian tube: those of communication join the carotid plexus in the carotid canal, the petrosal branch of the Vidian nerve, and otic ganglion.

The **carotid branches** are several filaments which follow the trunk of the internal carotid artery, and communicate with the nervi molles of the sympathetic and pharyngeal branch of the pneumogastric.

The **muscular branch** divides into filaments, which are distributed to the stylo-pharyngeus, and constrictor muscles.

The **pharyngeal branches** are two or three filaments which are distributed to the pharynx and unite with the pharyngeal branches of the pneumogastric and sympathetic nerve to form the *pharyngeal plexus.*

The **tonsillitic branches** proceed from the glosso-pharyngeal nerve, near its termination; they form a plexus (circulus tonsillaris) around the base of the tonsil, from which numerous filaments are given off to the mucous membrane of the fauces and soft palate. These filaments communicate with the descending palatine branches of Meckel's ganglion.

The **lingual branches** enter the substance of the tongue beneath the hyo-glossus and stylo-glossus muscle, and are distributed to the mucous membrane of the side and base of the tongue, and to the epiglottis and fauces.

PNEUMOGASTRIC or **VAGUS NERVE**; par vagum; tenth pair of Soemmering.—The pneumogastric is the nerve of the re-

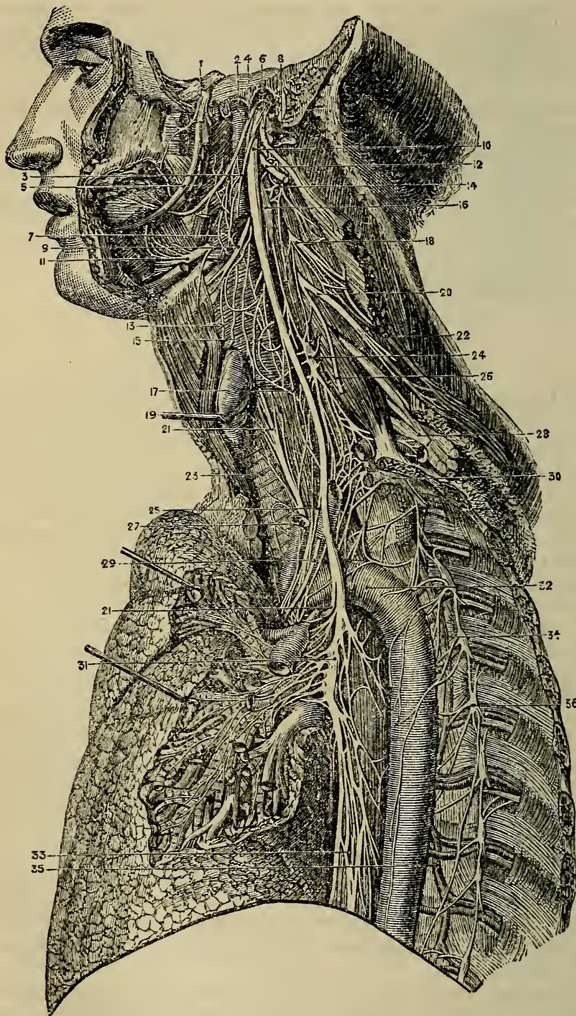


FIG. 300.—Distribution of the eighth pair of nerves on the left side. 1. Gasserian ganglion of fifth nerve. 2. Internal carotid artery. 3. Pharyngeal branch of pneumogastric. 4. Glosso-pharyngeal nerve. 5. Gustatory nerve (fifth). 6. Spinal accessory nerve. 7. Middle constrictor of pharynx. 8. Internal jugular vein (cut). 9. Superior laryngeal nerve. 10. Ganglion of trunk of pneumogastric nerve. 11. Hypoglossal nerve on hyo-glossus. 12. Ditto communicating with eighth and

first cervical nerve. 13. External laryngeal nerve. 14. Second cervical nerve looping with first. 15. Pharyngeal plexus on inferior constrictor. 16. Superior cervical ganglion of sympathetic. 17. Superior cardiac nerve of pneumogastric. 18. Third cervical nerve. 19. Thyroid body. 20. Fourth cervical nerve. 21, 21. Left recurrent laryngeal nerve. 22. Spinal accessory communicating with cervical nerves. 23. Trachea. 24. Middle cervical ganglion of sympathetic, 25. Middle cardiac nerve of pneumogastric. 26. Phrenic nerve (cut). 27. Left carotid artery. 28. Brachial plexus. 29. Phrenic nerve (cut). 30. Inferior cervical ganglion of sympathetic. 31. Pulmonary plexus of pneumogastric. 32. Thoracic aorta. 33. Œsophageal plexus. 34. Vena azygos minor superior. 35. Vena azygos minor inferior. 36. Gangliated cord of sympathetic.

spiratory organs and upper part of the alimentary canal, supplying branches to the larynx, trachea, lungs, pharynx, œsophagus, and stomach, and also giving branches to the heart. It *arises* by ten or fifteen filaments from the groove between the olivary and restiform bodies, immediately below the glosso-pharyngeal, and passes out of the skull through the inner extremity of the jugular foramen, enclosed in a sheath of dura mater common to it and the spinal accessory. The nerve then takes its course down the side of the neck, lying at first between the internal jugular vein and internal carotid artery, and lower down behind and between that vein and the common carotid artery and enclosed in the same sheath. At the root of the neck the course of the nerve on the two sides is different. The *right nerve* enters the chest by passing between the subclavian artery and vein, and descends by the side of the trachea to the posterior part of the root of the right lung ; it then proceeds as a double cord along the posterior aspect of the œsophagus to the corresponding side of the stomach ; the two cords reuniting at the lower part of the œsophagus. The *left nerve* enters the chest between the left common carotid and subclavian artery lying behind the left vena innominata ; it then crosses the arch of the aorta, and reaches the posterior part of the root of the left lung, whence it descends, by one or two cords, along the anterior aspect of the œsophagus to the front part of the stomach.

In the jugular foramen, the pneumogastric nerve presents a small round ganglion, the *superior ganglion* or *ganglion of the root;* and immediately at its exit a gangliform swelling, nearly an inch in length, the *inferior ganglion* or *ganglion of the trunk.*

The fibres of origin of the pneumogastric nerve may be traced to a mass of nerve cells placed beneath the floor of the fourth ventricle. The nuclei of the right and left sides are in contact at the point of the calamus scriptorius, but are separated above by the nuclei of the hypoglossal nerve.

The **branches** of the pneumogastric nerve are branches of communication and branches of distribution.

The **branches of communication** proceed from the ganglia ; from the superior ganglion one or two branches pass to the spinal accessory ; one or two to the superior ganglion of the sympathetic ; and one to the inferior ganglion of the glosso-pharyngeal. From the inferior ganglion there pass off branches to the hypoglossal ; branches to the superior cervical ganglion of the sympathetic, and branches to the loop between the first and second cervical nerve.

The **branches of distribution** are—

Auricular,	Anterior pulmonary,
Pharyngeal,	Posterior pulmonary,
Superior laryngeal,	Œsophageal,
Cardiac,	Gastric.
Inferior or recurrent laryngeal.	

The **auricular branch** (Arnold's nerve) is given off from the lower part of the jugular ganglion, or from the trunk of the nerve immediately below it, and receives immediately after its origin a small branch of communication from the glosso-pharyngeal. It then passes outwards behind the jugular vein, and at the outer side of that vessel enters a small canal (p. 83), in the jugular fossa of the temporal bone. Guided by that canal it reaches the descending part of the aqueductus Fallopii and communicates with the facial nerve, it then passes outwards through a small fissure situated between the mastoid process and external auditory process (auditory fissure), and reaching the surface of the bone communicates with the posterior auricular nerve and is distributed to the back part of the pinna.

The **pharyngeal** nerve arises from the upper part of the ganglion of the trunk, and crosses behind the internal carotid artery to the upper border of the middle constrictor, upon which it forms the *pharyngeal plexus* assisted by branches from the glosso-pharyngeal, superior laryngeal, and sympathetic. The pharyngeal plexus is distributed to the muscles and mucous membrane of the pharynx.

The **superior laryngeal** nerve arises from the inferior ganglion, and descends behind the internal carotid artery to the opening in the thyro-hyoid membrane, through which it passes with the superior laryngeal artery, and is distributed to the mucous membrane of the larynx and arytenoideus muscle. On the latter, and behind the cricoid cartilage, it communicates with the recurrent laryngeal nerve. Behind the internal carotid it gives off the **external laryngeal branch**, which sends a twig to the pharyngeal plexus, and then descends to supply the inferior constrictor, crico-thyroid muscle and thyroid gland. This branch communicates inferiorly with the recurrent laryngeal and sympathetic nerve.

The **cardiac branches**, two or three in number, arise from the upper and lower part of the cervical portion of the nerve. Those from above communicate with cardiac branches of the sympathetic. One large branch (*inferior cardiac*) is given off just before the nerve enters the chest; on the *right* this branch descends by the side of the arteria innominata to the deep cardiac plexus; on the *left* it passes in front of the arch of the aorta to the superficial cardiac plexus. One or two cardiac branches also proceed from the thoracic portion of the right pneumogastric nerve.

The **inferior**, or **recurrent laryngeal nerve**, curves around the subclavian artery on the right, and the arch of the aorta on the left side. It ascends in the groove between the trachea and

œsophagus, and piercing the lower fibres of the inferior constrictor muscle enters the larynx close to the articulation of the inferior cornu of the thyroid with the cricoid cartilage. It is distributed to all the muscles of the larynx, with the exception of the crico-thyroid, and communicates on the arytenoideus muscle with the superior laryngeal nerve. As it curves around the subclavian artery and aorta it gives branches (cardiac) to the heart and root of the lungs; and as it ascends the neck it distributes filaments to the œsophagus and trachea, and communicates with the external laryngeal nerve and sympathetic.

FIG. 301. — Origin and distribution of the glosso-pharyngeal, pneumogastric, and spinal accessory nerve. 1, 3, 4. Medulla oblongata. 1. Anterior pyramid. 2. Pons Varolii. 3. Olivary body. 4. Restiform body. 5. Facial nerve. 6. Origin of the glosso-pharyngeal. 7. Ganglion of Andersch. 8. Trunk of the nerve. 9. Spinal accessory nerve. 10. Superior ganglion of the pneumogastric. 11. Inferior ganglion. 12. Trunk. 13. Pharyngeal branch forming the pharyngeal plexus (14) assisted by a branch from the glosso-pharyngeal (8), and one from the superior laryngeal nerve (15). 16. Cardiac branches. 17. Recurrent laryngeal branch. 18. Anterior pulmonary and cardiac branches. 19. Posterior pulmonary branches. 20. Œsophageal plexus. 21. Gastric branches. 22. Origin of the spinal accessory nerve. 23. Branch to the sterno-mastoid muscle. 24. Branches to the trapezius.

The **anterior pulmonary branches,** two or three in number, are distributed upon the anterior aspect of the root of the lungs, forming, with branches from the cardiac plexuses, the *anterior pulmonary plexus.*

The **posterior pulmonary branches,** more numerous and larger than the anterior, are distributed on the posterior aspect of the root of the lungs; they are joined by filaments from the third and fourth thoracic ganglia of the sympathetic, and form the *posterior pulmonary plexus.*

Œsophageal branches are given off by the pneumogastric nerves above the root of the lungs; below that point, the trunks of the nerves, divided into several cords, form a plexus around the œsophagus, the right

and left nerves communicating with each other. This plexus accompanies the œsophagus to the stomach, and is the *œsophageal plexus* (plexus gulæ).

The **gastric branches** are the terminal filaments of the pneumo-

Fig. 302. — Diagram of the eighth, ninth, and sympathetic nerves. 1. Facial nerve. 2. Glosso-pharyngeal nerve, with its petrous ganglion. 3. Pneumogastric nerve. 4. Spinal accessory nerve. 5. Hypoglossal nerve. 6. Superior cervical ganglion of sympathetic. 7. Loop between first and second cervical nerves. 8. Carotid branch of sympathetic. 9. Tympanic nerve (Jacobson). 10. Its branch to carotid plexus. 11. Its branch to Eustachian tube. 12. Its branch to fenestra ovalis. 13. Its branch to fenestra rotunda. 14. Its union with small superficial petrosal nerve. 15. Its union with large superficial petrosal nerve. 16. Otic ganglion. 17. Auricular nerve of pneumogastric. 18. Junction of pneumogastric with spinal accessory. 19. Junction of ninth nerve and first cervical nerve. 20. Junction of mastoid branch of spinal accessory and second cervical nerve. 21. Pharyngeal plexus. 22. Superior laryngeal nerve. 23. External laryngeal nerve. 24. Middle cervical ganglion of sympathetic. 25. Junction of digastric nerve (seventh) with glosso-pharyngeal.

gastric nerves; they are spread out upon the anterior and posterior surface of the stomach, and are likewise distributed to the omentum, spleen, pancreas, liver, and gall-bladder. The branches of the anterior aspect of the stomach proceed from the left nerve and communicate with the hepatic plexus in the lesser omentum; those of

the posterior aspect are derived from the right nerve and communicate with the solar plexus.

SPINAL ACCESSORY NERVE; **eleventh pair** of Soemmering.—The spinal accessory, a nerve of motion, *arises* by several filaments from the side of the spinal cord as low down as the fifth or sixth cervical nerve, and ascends behind the ligamentum denticulatum, and between the anterior and posterior roots of the spinal nerves, to the foramen lacerum posterius. It communicates in its course with the posterior root of the first cervical nerve, and entering the foramen lacerum, becomes applied against the posterior aspect of the superior ganglion of the pneumogastric, being contained in the same sheath of dura mater. The nerve then passes outwards and downwards, behind and sometimes in front of the internal jugular vein, to the upper and under part of the sterno-mastoid, pierces that muscle obliquely, and descends across the posterior triangle of the neck to the under surface of the trapezius, to which it is distributed, its branches being continued downwards to near the lower border of the muscle.

The **branches of communication** of the spinal accessory are one or two small branches from the superior ganglion of the pneumogastric, and a large branch which joins the pneumogastric between the two ganglia.

Its **branches** of distribution are **muscular** branches to the sterno-mastoid and trapezius. In the substance of the sterno-mastoid it communicates with branches of the cervical plexus, and in the posterior triangular space with the third and fourth cervical nerve.

The pneumogastric and spinal accessory nerve together (nervus vagus cum accessorio) resemble a spinal nerve, of which the former with its ganglion is the posterior and sensitive root, the latter the anterior and motor root. The deep origin of the spinal accessory may be traced into the grey substance of the floor of the fourth ventricle.

NINTH NERVE.

Ninth pair of Willis; **twelfth pair** of Soemmering. **Hypoglossal nerve**; **lingual.**—The hypoglossal is a nerve of motion, distributed to all the muscles of the tongue, most of those attached to the os hyoides, and the sterno-thyroid. It *arises* from the groove between the anterior pyramid and olivary body by ten or fifteen filaments, which are collected into two bundles, and escape from the cranium through the anterior condylar foramen. At its exit from the cranium, the nerve lies behind the internal carotid artery and internal jugular vein, then passing forward between the artery and vein it descends to a point parallel with the angle of the lower jaw. It next curves forward around the occipital artery, with which it forms a loop, and crossing the external carotid and lower part of the hyo-glossus muscle to the genio-hyo-glossus, sends filaments onwards with the anterior fibres of that muscle as far as the tip of

the tongue. While resting on the hyo-glossus muscle it is flattened, and beneath the mylo-hyoid communicates with the gustatory nerve.

At its origin, the hypoglossal nerve sometimes communicates with the posterior root of the first cervical nerve. Its *deep origin* may be traced to one of the nuclei of grey substance, in the floor of the fourth ventricle, where it decussates with its fellow of the opposite side.

The **branches** of the hypoglossal nerve are—branches of communication and branches of distribution.

The **branches of communication** of the hypoglossal nerve are—several to the pneumogastric, with which nerve it is closely united;

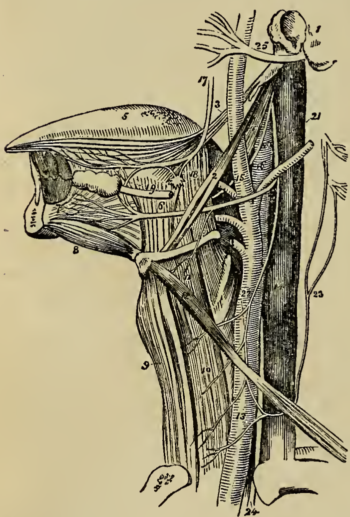


FIG. 303.—Anatomy of the side of the neck, showing the nerves of the tongue. 1. Temporal bone. 2. Stylo-hyoid muscle. 3. Stylo-glossus. 4. Stylo-pharyngeus. 5. Tongue. 6, 18. Hyo-glossus muscle. 7. Genio-hyo-glossus. 8. Genio-hyoid. 9. Sterno-hyoid muscle. 10. Sterno-thyroid. 11. Thyro-hyoid, upon which the thyro-hyoid branch of the hypoglossal nerve is seen ramifying. 12. Omo-hyoid crossing the common carotid artery (13), and internal jugular vein (14). 15. External carotid giving off its branches. 16. Internal carotid. 17. Gustatory nerve giving a branch to the submaxillary ganglion (18), and communicating a little farther on with the hypoglossal nerve. 19. Submaxillary, or Wharton's duct, passing forwards to the sublingual gland. The submaxillary ganglion is the small round body between figures 18 and 19. 20. Glosso-pharyngeal nerve. 21. Hypoglossal nerve curving around the occipital artery. 22. Descendens noni nerve, forming a loop with (23) the communicans noni, which is seen arising by filaments from the upper cervical nerves. 24. Pneumogastric nerve. 25. Facial nerve.

one or two with the superior cervical ganglion of the sympathetic; and one or two with the loop between the first and second cervical nerve.

The **branches of distribution** are—

Descendens noni, Thyro-hyoid, Muscular.

The **descendens noni** is a long and slender nerve, which quits the hypoglossal just as it is about to form its arch around the occipital artery, and descends on the sheath of the carotid vessels. Just below the middle of the neck it forms a loop with a long branch (communicans noni) derived from the second and third cervical nerve. From the convexity of this loop branches are sent to the sterno-hyoid, sterno-thyroid, and both bellies of the omo-hyoid;

sometimes also a twig is given off to the cardiac plexus, and occasionally one to the phrenic nerve. If the descendens noni be traced to its origin, it will be found to be composed of a branch from the hypoglossal, and one from the first and second cervical nerves; occasionally it receives also a filament from the pneumogastric.

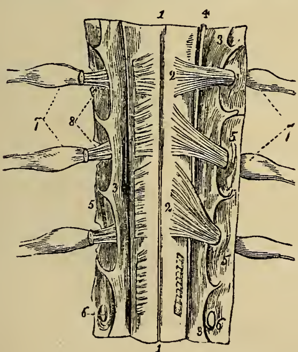
The **thyro-hyoid** nerve is a small branch distributed to the thyrohyoid muscle. It is given off by the trunk of the hypoglossal near the posterior border of the hyo-glossus, and descends obliquely over the great cornu of the os hyoides.

The **muscular branches** are given off where the nerve is covered in by the mylo-hyoid muscle, and rests on the hyo-glossus; several large branches take their course across the fibres of the genio-hyoglossus to reach the substance of the tongue. They are distributed to the hyo-glossus, genio-hyoid, genio-hyo-glossus, and stylo-glossus muscles. On the hyo-glossus muscle, the branches of the hypoglossal nerve communicate with those of the gustatory nerve.

SPINAL NERVES.

There are thirty-one pairs of spinal nerves, each arising by two roots, an anterior or motor root, and a posterior or sensory root.

The **anterior roots** proceed from the anterior lateral sulcus, which



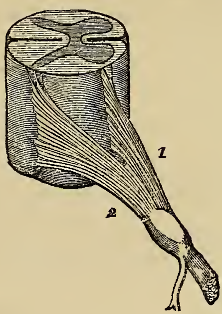


FIG. 304.—Part of the cervical portion of the spinal cord, viewed on its posterior aspect; showing its membranes and the posterior roots of the spinal nerves. 1, 1. Posterior median fissure. 2, 2. Posterior roots of the cervical nerves; on the opposite side the corresponding roots are cut through near their origin. 3, 3. Ligamentum denticulatum. 4. Spinal accessory nerve, ascending between the posterior roots and ligamentum denticulatum. 5, 5. Dura mater. 6, 6. Openings in the dura mater for the passage of the roots of the nerve. 7, 7. Ganglia on the posterior roots. 8. Anterior roots. The posterior roots have been cut away in order to show each anterior root proceeding to join the nerve beyond the ganglion.

FIG. 305.—Roots of the spinal nerves. 1. Anterior root. 2. Posterier root.

marks the division of the anterior from the posterior part of the antero-lateral column of the spinal cord, and gradually approach towards the anterior median fissure as they descend.

The **posterior roots**, more regular than the anterior, proceed from the posterior lateral sulcus; they are larger, and the filaments of origin more numerous than those of the anterior roots; and in the intervertebral foramina there is a ganglion on each of their roots. The first cervical nerve forms an exception to these characters; its posterior root is smaller than the anterior; it often joins, in whole or in part, the spinal accessory nerve, and sometimes the hypoglossal; it has frequently no ganglion, and when the ganglion exists, it is often situated within the dura mater, the latter being the usual position of the ganglia of the last two pairs of spinal nerves.

After the formation of a ganglion, the two roots unite, and constitute a spinal nerve, which escapes through the intervertebral foramen, and separates into an **anterior division** for the supply of the front aspect of the body, and a **posterior division** for the posterior aspect. In the first cervical, last sacral, and coccygeal nerve this division takes place within the dura mater; and in the upper four sacral nerves, externally to that cavity, but within the sacral canal. The anterior cords, with the exception of the first two cervical nerves, are larger than the posterior; an arrangement which is proportioned to the larger extent of surface they are required to supply. Both divisions are compound—that is to say, they contain both motor and sensory filaments.

The SPINAL NERVES are classed as follows:—

Cervical	8 pairs
Dorsal	12 „
Lumbar	5 „
Sacral	5 „
Coccygeal	1 „

The cervical nerves pass off transversely from the spinal cord; the dorsal are oblique in direction; the lumbar and sacral, vertical; the latter form the large assemblage of nerves, at the termination of the cord, called *cauda equina.* The cauda equina occupies the lower third of the spinal canal.

CERVICAL NERVES.

The cervical nerves increase in size from above downwards; the first (suboccipital) passes out of the spinal canal between the occipital bone and atlas; the second between the posterior ring of the atlas and the lamina of the axis; and the last between the last cervical and first dorsal vertebra. Each nerve, at its escape from the intervertebral foramen, divides into an anterior and a posterior cord. The anterior cords of the four upper cervical nerves form the *cervical plexus;* the posterior cords, the *posterior cervical plexus.* The anterior cords of the four inferior cervical together with the first dorsal form the brachial plexus.

ANTERIOR CERVICAL NERVES.—The anterior cord of

the **first cervical** or **suboccipital nerve** escapes from the vertebral canal through the groove on the posterior arch of the atlas, which supports the vertebral artery, lying beneath that vessel. It descends in front of the transverse process of the atlas, sends twigs to the rectus lateralis and rectus anticus minor, and forms an anastomotic loop by communicating with an ascending branch of the second nerve. Branches from this loop communicate with the pneumogastric nerve, hypoglossal nerve, and first cervical ganglion of the sympathetic.

The anterior cord of the **second cervical nerve**, at its exit from the intervertebral foramen between the atlas and axis, gives twigs to the rectus anticus major, scalenus medius, and levator anguli scapulæ, and divides into three branches: *ascending* branch, which completes the arch of communication with the first nerve; and two *descending* branches, which form loops with corresponding branches of the third nerve.

The anterior cord of the **third cervical nerve**, double the size of the preceding, divides at its exit from the intervertebral foramen into several branches, some of which are distributed to the rectus major, longus colli, and scalenus medius, while others communicate and form loops and anastomoses with the second and fourth nerve.

The anterior cord of the **fourth cervical nerve**, equal in size with the preceding, sends twigs to the rectus major, longus colli, and levator anguli scapulæ, communicates by anastomosis with the third, and sends a small branch downwards to the fifth nerve. Its principal branches pass downwards and outwards across the posterior triangle of the neck, towards the clavicle and acromion.

The anterior cords of the **fifth, sixth, seventh,** and **eighth** cervical nerves will be described with the brachial plexus, of which they form a part.

CERVICAL PLEXUS.—The cervical plexus is constituted by the loops of communication and anastomoses which take place between the anterior cords of the first four cervical nerves. The plexus rests on the levator anguli scapulæ, posterior and middle scalenus, and splenius colli muscle, and is covered in by the sterno-mastoid and platysma.

The **branches** of the cervical plexus may be arranged into three groups, superficial ascending, superficial descending, and deep:—

Superficial	*Ascending,*	Superficialis colli, Auricularis magnus, Occipitalis minor.
	Descending,	Acromial, Clavicular, Sternal.
Deep		Communicating branches, Communicans noni, Muscular, Phrenic.

The **superficialis colli** is formed by communicating branches from the second and third cervical nerves; it curves around the posterior border of the sterno-mastoid, and crosses obliquely behind the external jugular vein to the anterior border of that muscle, where it pierces the deep cervical fascia and divides into an ascending and a descending branch.

The *ascending branch* passes upwards to the submaxillary region, and divides into four or five filaments, some of which pierce the platysma myoides, and supply the integument as high as the chin and lower part of the face; while others form a plexus with the inframaxillary branches of the facial nerve beneath the platysma. One or two filaments from this branch accompany the external jugular vein.

The *descending branch* pierces the platysma, and is distributed to the integument of the front of the neck as far downwards as the sternum.

The **auricularis magnus,** the largest of the three ascending branches of the cervical plexus, also proceeds from the second and third cervical nerve; it curves around the posterior border of the sterno-mastoid, and ascends upon that muscle, lying parallel with the external jugular vein, to the parotid gland, where it divides into an anterior and a posterior branch.

The *anterior branch* is distributed to the integument over the parotid gland, and to the gland itself, communicating with the facial nerve.

The *posterior branch* ascends behind the ear, where it divides into *auricular branches*, supplying the pinna; and a *mastoid branch* which communicates with the posterior auricular branch of the facial and is distributed to the integument behind the ear. The auricular branches communicate with the auricular offsets of the facial nerve, pneumogastric nerve, and occipitalis minor.

The **occipitalis minor** arises from the second cervical nerve; it curves around the posterior border of the sterno-mastoid above the preceding, and ascends upon that muscle, parallel with its posterior border, to the lateral and posterior aspect of the cranium. It is distributed to the integument, to the occipital portion of the occipito-frontalis and attollens auriculam, and communicates with the occipitalis major, auricularis magnus, and posterior auricular branch of the facial.

Superficial Descending Branches.—The *acromial* and *clavicular* are two or three large nerves which proceed from the fourth cervical nerve, and pass downwards in the posterior triangle of the neck; they pierce the deep fascia, and crossing the clavicle are distributed to the integument of the front of the chest from the sternum to the acromion; hence their designation, *clavicular* and *acromial.* The most anterior of the branches is named *sternal,* from its destination, and the outermost branch passes over the clavicular attachment of the trapezius, to reach the shoulder.

Deep Branches.—The *communicating branches* are filaments

which arise from the loop between the first and second cervical nerve, and pass inwards to communicate with the sympathetic, pneumogastric, and hypoglossal nerve. The first three cervical nerves send branches to the first cervical ganglion ; the fourth sends a branch to the trunk of the sympathetic, or to the middle cervical ganglion. From the second cervical nerve a large branch is given off, which joins the spinal accessory nerve.

The **communicans noni** is a long and slender branch of communication between the cervical plexus and descendens noni ; it is formed by filaments from the second and third cervical nerve; descends at the outer side of the internal jugular vein, and forms a loop with the descendens noni over the sheath of the carotid vessels.

The **muscular branches** of the cervical plexus are distributed to the muscles of the front of the vertebral column and side of the neck. From the loop, between the first and second nerve, branches are given to the anterior recti ; from the *second* cervical nerve a branch proceeds to the sterno-mastoid ; from the *third* and *fourth* nerve branches are distributed to the trapezius, levator anguli scapulæ, scalenus medius, and scalenus posticus. The branch to the trapezius communicates with the spinal accessory nerve.

The **phrenic nerve** (internal respiratory of Bell) is formed by the union of filaments from the fourth and fifth cervical nerve, and is joined by a communication from the combined cord of the fifth and sixth and a filament from the sympathetic. It descends to the root of the neck, resting on the scalenus anticus muscle, crosses the first portion of the subclavian artery, and enters the chest between it and the subclavian vein, passing over the commencement of the internal mammary artery. Within the chest it passes downwards through the middle mediastinum, lying between the pleura and pericardium, and in front of the root of the lung, to the diaphragm ; near the diaphragm it divides into branches which pierce that muscle, and are distributed on its under surface. Some of its filaments reach the abdomen through the openings for the œsophagus and vena cava, and communicate with the phrenic and solar plexus, and on the right side with the hepatic plexus. The *left phrenic nerve* is longer than the right, from the inclination of the heart to the left side, and crosses the arch of the aorta. The *right nerve* is situated more deeply in the upper part of the chest than the left, and lies in contact with the right vena innominata and superior vena cava. Each nerve is accompanied by the arteria comes nervi phrenici, a branch of the internal mammary, and by two veins.

POSTERIOR CERVICAL NERVES.—The posterior cords of the *cervical nerves* issue from between the transverse processes ; and divide into an internal and external branch. The *internal* branch is directed inwards towards the middle of the spine, and, becoming cutaneous near the spinous processes of the vertebræ, is then reflected outwards to supply the integument. The *external* branch, smaller than the internal, is distributed to the muscles of the outer portion of the vertebral groove.

The posterior cord of the **first cervical nerve** (sub-occipital), larger than the anterior, escapes from the vertebral canal through the opening for the vertebral artery, lying posteriorly to that vessel, and emerges in the triangular space formed by the rectus posticus major, obliquus superior, and obliquus inferior. It is distributed to the recti, obliqui, and complexus, and sends a branch downwards to communicate with the second cervical nerve ; it has no external branch.

The posterior cord of the **second cervical nerve** is three or four times larger than its anterior cord, and exceeds in size the other posterior cervical nerves. Its *internal branch* is the *occipitalis major nerve.*

The posterior cord of the **third cervical nerve** is smaller than the second, but larger than the fourth ; its *internal branch* gives off a cutaneous branch to the back of the cranium.

The posterior cords of the remaining cervical nerves go on progressively decreasing in size to the seventh.

The **internal branches** of the **second, third, fourth,** and **fifth** nerve lie on the semispinalis colli muscle, and are closely connected with a fascia which separates that muscle from the complexus. The second and third, with a branch from the first, constitute the *posterior cervical plexus;* and all the branches in their course to the surface pierce the complexus and trapezius and some the splenius.

The **internal branches** of the **sixth, seventh,** and **eighth** nerve pass beneath the semispinalis colli, and are lost in the muscles without reaching the integument.

The **occipitalis major nerve,** the internal branch of the posterior cord of the second cervical nerve, ascends obliquely inwards between the obliquus inferior and complexus, pierces the complexus and trapezius after passing for a short distance between them, and ascends the posterior aspect of the head in company with the occipital artery. Soon after its escape from the trapezius, it receives a branch from the third cervical, and divides into numerous branches, which are distributed to the occipitalis muscle and to the integument as far as the summit of the head. It communicates with the occipitalis minor nerve, and sends an *auricular* branch to the back of the ear.

BRACHIAL PLEXUS.

The brachial or axillary plexus of nerves is formed by communications between the anterior cords of the four lower cervical nerves and first dorsal. These nerves are alike in size, and their mode of disposition in the formation of the plexus is as follows : the fifth and sixth unite to form a common trunk, the eighth and first dorsal unite in like manner, the seventh runs alone ; each of these three trunks then divides into an anterior and posterior branch. The anterior branch of the trunk, derived from the fifth and sixth, receives the anterior branch of the seventh, and these together form

the **outer cord.** The anterior branch of the trunk formed by the eighth and first dorsal constitutes the **inner cord.** The three posterior branches unite to form the **posterior cord.***

The plexus is broad in the neck, narrows as it descends into the axilla, and again enlarges at its lower part, where it divides into its terminal branches.

The brachial plexus communicates with the cervical plexus by means of a branch from the fourth to the fifth nerve, and receives branches from the two inferior cervical ganglia of the sympathetic.

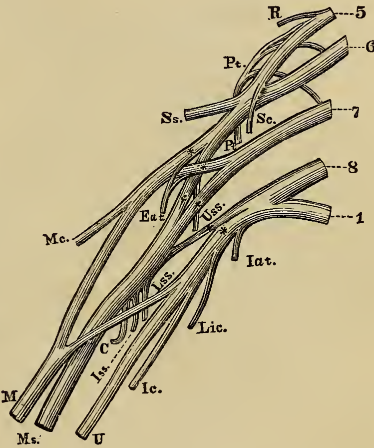


FIG. 306.—Nerves forming the brachial plexus. The numerals 5, 6, 7, 8, and 1, refer to the four lower cervical and first dorsal nerves. *R.* Nerve to the rhomboid muscles. *Pt.* Posterior or long thoracic. *Ss.* Supra-scapular. *Sc.* Nerve to the subclavius. *Uss.* Upper subscapular. *Lss.* Long subscapular. *Iss.* Inferior subscapular. *Eat.* External anterior thoracic. *Iat.* Internal anterior thoracic. *Mc.* Musculo-cutaneous. *M.* Median. *Ms.* Musculo-spiral. *U.* Ulnar. *Ic.* Internal cutaneous. *Lic.* Lesser internal cutaneous. *** Anterior and (†††) posterior branches of the three primary trunks. *C.* Circumflex.

The plexus is in relation in the neck with the scaleni muscles; lower down it is placed between the clavicle and subclavius muscle above, and the first rib and first serration of the serratus magnus muscle below. In the axilla, it is situated at first to the outer side of and then behind the axillary artery, resting by its outer border against the tendon of the subscapularis muscle. Lower down it completely surrounds the artery.

The **branches** of the brachial plexus are: from the **outer cord,** one of the anterior thoracic nerves, the musculo-cutaneous nerve, and the outer head of the median; from the **inner cord,** the other anterior thoracic nerve, inner head of the median, internal cutaneous, lesser internal cutaneous of Wrisberg, and ulnar; from the **posterior cord,** the subscapular nerves, circumflex, and musculo-spiral.

Besides these, the brachial plexus, while in the neck, gives off several *superior muscular branches;* one to the subclavius muscle, one to the rhomboid muscles and levator anguli scapulæ; one of large size, the *suprascapular;* and a long and slender nerve which

* This description and the accompanying diagram are taken from a paper by Mr. R. Clement Lucas in *Guy's Hospital Reports,* 1875.

passes down the thoracic wall of the axilla, the *posterior thoracic*, or external respiratory nerve of Bell.

In reference to their distribution, the branches of the brachial plexus may be arranged in three groups, *thoracic*, *scapular*, and *brachial*, as follows :—

Thoracic.

Anterior thoracic,
Posterior thoracic.

Scapular.

Superior muscular,
Suprascapular,
Subscapular.

Brachial.

Musculo-cutaneous,
Internal cutaneous,
Lesser internal cutaneous,
Median,
Ulnar,
Musculo-spiral,
Circumflex.

The spinal nerves with which each of the nerves of the brachial plexus is connected are shown in the subjoined table taken from *Quain's Anatomy;* the higher numbers refer to the cervical nerves, the unit to the dorsal nerve :—

Subscapular from	5, 6, 7, 8.	Ulnar	8, 1, or 7, 8, 1.
Circumflex . .	5, 6, 7, 8.	Internal cutaneous	8, 1.
Musculo-spiral .	5, 6, 7, 8.	Lesser internal cutaneous . .	8, 1.
External cutaneous	5, 6, 7.	Anterior thoracic, Outer	5, 6, 7.
Median	5, 6, 7, 8, 1.	Anterior thoracic, Inner	8, 1.

The **anterior thoracic nerves**, two in number, proceed, one from the external cord of the plexus, the other from the internal cord. The former, the *external* or superficial branch, crosses the axillary artery in the space above the pectoralis minor to the front of the chest, and is distributed to the pectoralis major muscle. The *internal* or deeper branch issues from between the axillary artery and vein, and after forming a loop of communication with the preceding is distributed to the under surface of the pectoralis minor and major, generally piercing the former to reach the latter.

The **posterior thoracic**, or external respiratory of Bell, is formed by the junction of two offsets, one from the fifth, the other from the sixth cervical nerve; it crosses behind the brachial plexus to reach the side of the chest, and descends on the serratus magnus to the lower part of that muscle, to which it is distributed.

The **superior muscular nerves** are small branches to the longus colli and scaleni, and branches to the rhomboidei and subclavius.

The **rhomboid branch** proceeds from the fifth cervical nerve, and passing backwards through the fibres of the scalenus medius, and beneath the levator anguli scapulæ, is distributed to the under surface of the rhomboid muscles. In its course it sometimes gives a branch to the levator anguli scapulæ.

The **subclavian branch**, proceeding from the cord formed by the fifth and sixth nerve, descends in front of the subclavian artery, to

the subclavius muscle. This nerve usually communicates with the phrenic at its entrance into the chest.

The **suprascapular nerve** arises from the trunk formed by the union of fifth and sixth cervical nerves and proceeds obliquely outwards, along with the artery of the same name to the suprascapular

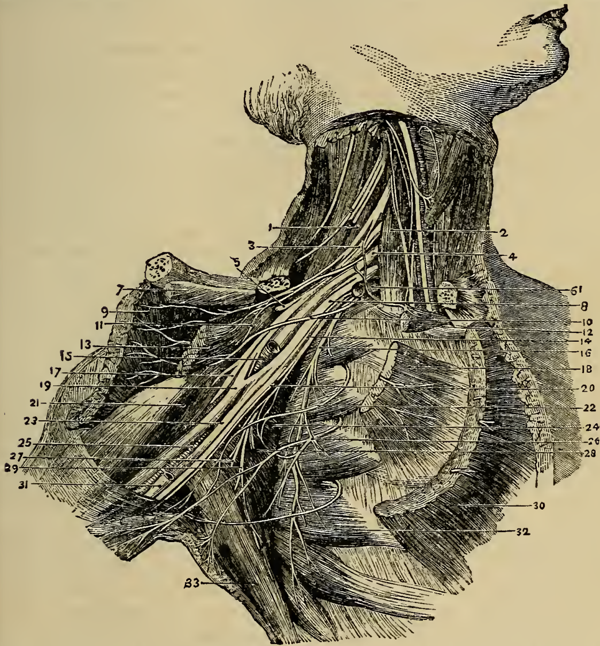


FIG. 307.—The nerves of the axilla. 1. Scalenus medius. 2. Scalenus anticus. 3. Cord formed by fifth and sixth cervical nerves. 4. Seventh cervical nerve. 5. Suprascapular nerve. 6. Subclavian artery (cut). 7. Insertion of subclavius. 8. Cord formed by eighth cervical and first dorsal nerves. 9. Pectoralis major (reflected). 10. Internal anterior thoracic nerve. 11. External anterior thoracic nerve. 12. Origin of subclavius. 13. Pectoralis minor (reflected). 14. Internal cutaneous nerve. 15. Axillary artery (cut). 16. Posterior thoracic nerve (Bell). 17. Musculo-cutaneous nerve. 18. Origin of pectoralis minor. 19. Median nerve. 20. Nerve of Wrisberg. 21. Coraco-brachialis. 22. Intercosto-humeral nerve. 23. Ulnar nerve. 24. Subscapularis. 25. Brachial artery. 26. Lateral cutaneous branch of third intercostal nerve. 27. Middle subscapular nerve. 28. Short subscapular nerve. 29. Long subscapular nerve. 30. Pectoralis major (cut). 31. Basilic vein. 32. Serratus magnus. 33. Latissimus dorsi.

notch; it passes through the notch, crosses the supra-spinous fossa beneath the supra-spinatus muscle, and running in front of the concave margin of the spine of the scapula enters the infra-spinous fossa, to be distributed to the supra-spinatus and infra-spinatus muscle, and sends two or three filaments to the shoulder-joint.

The **subscapular nerves** are three in number: one arises from the brachial plexus above the clavicle, the others from the posterior cord of the plexus within the axilla. The first or smallest supplies the upper part of the subscapularis muscle; the second and largest (*long subcsapular*) follows the course of the subscapular artery, and is distributed to the latissimus dorsi; the third supplies the lower part of the subscapularis muscle and teres major.

BRACHIAL NERVES.—The brachial branches of the plexus are arranged in the following order: musculo-cutaneous, and one head of the median to the outer side of the artery; the other head of the median, internal cutaneous, lesser internal cutaneous, and ulnar, to its inner side; the circumflex and musculo-spiral behind.

The **MUSCULO-CUTANEOUS NERVE** (external cutaneous, perforans Casserii) arises from the brachial plexus in common with the external head of the median; pierces the coraco-brachialis muscle, and passes between the biceps and brachialis anticus to the outer side of the bend of the elbow, where it perforates the deep fascia, and divides into an anterior and posterior branch. These branches pass behind the median cephalic vein, the *anterior*, the larger of the two, taking the course of the radial vein and communicating with the radial nerve on the back of the hand; the *posterior* and smaller following the direction of the supinator longus, communicating with the internal cutaneous, and at the lower third of the forearm sending off an arterial twig, which accompanies the radial artery, to the wrist, and distributes filaments to the synovial membranes of the joint.

The musculo-cutaneous nerve supplies the coraco-brachialis, biceps, and brachialis anticus in the upper arm, and the integument of the outer side of the forearm as far as the wrist and hand.

The **INTERNAL CUTANEOUS NERVE**, one of the internal and smaller branches of the brachial plexus, arises from the plexus in common with the ulnar and internal head of the median, and passes down the inner side of the arm in company with the basilic vein, giving off several cutaneous filaments in its course. At about the middle of the upper arm it pierces the deep fascia by the side of the basilic vein and divides into two branches, external and internal. The *external branch*, the larger of the two, divides into several branches which pass in front of, and sometimes behind the median basilic vein at the bend of the elbow, and descend in the course of the palmaris longus muscle to the wrist, distributing filaments to the integument in their course and communicating with the anterior branch of the musculo-cutaneous on the outer side, and its own internal branch on the inner side of the forearm. The *internal branch* sends off several twigs to the integument over the inner condyle and olecranon, passes behind the inner condyle, and descends the forearm in the course of the ulnar vein as far as the wrist, supplying the integument of the inner side of the forearm, and communicating with the external branch of the same nerve in front, and the dorsal branch of the ulnar nerve at the wrist.

The **LESSER INTERNAL CUTANEOUS NERVE,** or **nerve of Wrisberg,** the smallest of the brachial nerves, arises with the preceding from the inner cord of the plexus, and issuing from beneath the axillary vein descends the inner side of the arm, to the middle of its posterior aspect, where it pierces the fascia and is distributed to the integument of the lower third of the upper arm as far as the olecranon. While in the axilla, the nerve of Wrisberg communicates with the intercosto-humeral nerve, and sometimes its place is taken by the latter.

The **MEDIAN NERVE,** named from its median position in the arm and forearm, arises by two heads which proceed from the outer and inner cord of the plexus and embrace the axillary artery. The nerve lies at first to the outer side of the brachial artery, but crosses it in the middle, sometimes in front and sometimes behind, and getting to its inner side descends to the bend of the elbow. It next passes between the two heads of the pronator radii teres and beneath the flexor sublimis digitorum, and runs down the middle of the forearm, lying between the latter

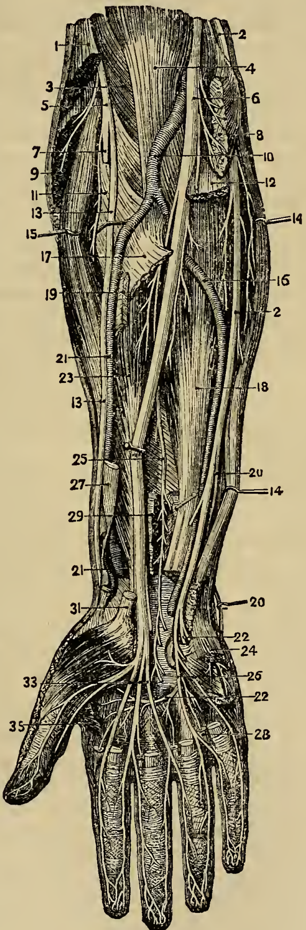


FIG. 308.—Deep dissection of the front of the forearm and hand. 1. Supinator longus (cut). 2, 2. Ulnar nerve. 3. Brachialis anticus. 4. Biceps. 5. Musculo-spiral nerve. 6. Median nerve. 7. Posterior interosseous nerve. 8. Pronator teres and flexor carpi radialis (cut). 9. Extensor carpi radialis longior (cut). 10. Brachial artery. 11. Supinator brevis. 12. Flexor sublimis digitorum (cut). 13, 13. Radial nerve. 14, 14. Flexor carpi ulnaris. 15. Extensor carpi radialis brevior. 16. Ulnar artery. 17. Radial origin of flexor sublimis digitorum (cut). 18. Flexor profundus digitorum. 19. Tendon of pronator teres. 20, 20. Dorsal branch of ulnar nerve. 21, 21. Radial artery. 22, 22. Deep branch of ulnar nerve. 23. Flexor longus pollicis. 24. Abductor minimi digiti. 25. Anterior interosseous nerve. 26. Digital branches of ulnar nerve. 27. Tendon of supinator longus. 28. One of the lumbricales muscles. 29. Pronator quadratus. 31. Tendon of flexor carpi radialis. 33. Digital branches of median nerve. 35. Adductor pollicis.

muscle and the flexor profundus to the wrist. It then dips beneath the annular ligament and enters the palm of the hand. Just above the wrist it is superficial, lying by the outer border of the tendons of the flexor sublimis digitorum. In the forearm the nerve is accompanied by a small branch of the anterior interosseous artery.

The **branches** of the median nerve are—

Muscular,	Superficial palmar,
Anterior interosseous,	Digital.

The **muscular branches** are given off by the nerves at the bend of the elbow; they are distributed to all the muscles of the anterior aspect of the forearm, with the exception of the flexor carpi ulnaris, and ulnar half of the flexor profundus. The branch to the pronator radii teres sends off reflected filaments to the elbow-joint.

The **anterior interosseous** is a large branch accompanying the anterior interosseous artery, and supplying the deep layer of muscles of the forearm, being lost inferiorly in the pronator quadratus.

The **superficial palmar branch** arises from the median at about the lower fourth of the forearm; it crosses the annular ligament, and is distributed to the integument of the palm of the hand, and ball of the thumb.

The median nerve as it enters the palm of the hand is of a reddish colour and is spread out and flattened; it divides into six branches, one muscular and five digital.

The **muscular branch** is distributed to the abductor pollicis, flexor ossis metacarpi pollicis, and radial half of the flexor brevis pollicis.

The **digital branches** are arranged as follows: *two* pass outwards to the thumb and supply its borders; the *third* runs along the radial side of the index finger, sending a twig to the first lumbricalis in its course; the *fourth* subdivides for the supply of the adjacent sides of the index and middle finger, and gives a twig to the second lumbricalis; the *fifth* receives a filament of communication from the ulnar nerve, and supplies the collateral branches of the middle and ring finger.

Opposite the base of the first phalanx, each nerve gives off a *dorsal branch* which runs along the border of the dorsum of the finger. Near its extremity the nerve divides into a *palmar* and a *dorsal* branch; the former supplying the sentient extremity of the finger; the latter the structures around and beneath the nail. The digital nerves in their course along the fingers lie to the inner side of and superficially to the arteries; and the nerve of one side of a finger has no communication with that of the opposite side.

It will be observed that the median nerve supplies all the muscles of the front of the forearm except the flexor carpi ulnaris and half the flexor profundus digitorum. In the hand it gives branches to those muscles of the thumb which lie to the radial side of the tendon of the flexor longus pollicis, and the two outer lumbricales; the latter muscles are supplied by this nerve because they are

connected with the tendons of that portion of the flexor profundus which derives its nerve supply from the median. The digital branches are distributed to the palmar aspect of the thumb, index, middle, and half the ring fingers.

The **ULNAR NERVE** is somewhat smaller than the median, behind which it lies, gradually diverging from it in its course. It arises from the inner cord of the brachial plexus in common with the internal head of the median and internal cutaneous nerve, and runs down the inner side of the arm, to the groove between the internal condyle and olecranon, resting on the internal head of the triceps, and accompanied by the inferior profunda artery. At the elbow it is superficial, and supported by the inner condyle, against which it may be compressed, giving rise to the thrilling sensation along the inner side of the forearm and little finger, popularly ascribed to striking the "funny bone." It then passes between the two heads of the flexor carpi ulnaris, and descends along the inner side of the forearm, crosses the annular ligament with the ulnar artery, and divides into two branches, superficial and deep palmar. At the commencement of the middle third of the forearm it comes into relation with the artery, and lies to the ulnar side of that vessel, as far as the hand.

The **branches** of the ulnar nerve are—

Articular,	Dorsal branch,
Muscular,	Superficial palmar,
Cutaneous,	Deep palmar.

The **articular branches** are several filaments to the elbow-joint, given off from the nerve while lying in the groove between the inner condyle and olecranon.

The **muscular branches** are distributed to the flexor carpi ulnaris and ulnar half of the flexor profundus digitorum.

The **cutaneous branch** proceeds from about the middle of the nerve, and descends upon the ulnar artery to the hand, giving twigs to the integument in its course. One branch from its upper part, sometimes a separate offset from the nerve and sometimes absent, pierces the fascia, and communicates with the internal cutaneous nerve.

The **dorsal branch** passes backwards beneath the tendon of the flexor carpi ulnaris, at the lower fourth of the forearm, and divides into branches which supply the integument and two fingers and a half on the posterior aspect of the hand, communicating with the radial nerve, with which it forms an arch.

The **superficial palmar branch**, after giving some twigs to the palmaris brevis and inner border of the hand, divides into three filaments, two of which are distributed, *one* to the ulnar side of the little finger, and *one* to the adjoining borders of the little and ring finger, while the third, a *communicating branch*, joins the median nerve.

The **deep palmar branch**, passes between the abductor and flexor

minimi digiti, to the deep palmar arch, supplying the muscles of the little finger, interossei, two ulnar lumbricales, adductor pollicis, and inner head of the flexor brevis pollicis.

The ulnar nerve supplies in the forearm the flexor carpi ulnaris and half the flexor profundus digitorum; in the hand it supplies all the muscles of the palm which lie to the ulnar side of the tendon of the long flexor of the thumb except the two radial lumbricales. Its cutaneous branches are distributed to one and a half fingers on the front and two and a half on the back of the hand.

The **MUSCULO-SPIRAL NERVE**, the largest branch of the brachial plexus, arises from its posterior trunk in common with the circumflex, and, descending behind the axillary and brachial artery, winds around the humerus between the triceps and the bone, and in company with the superior profunda artery, to the space between the brachialis anticus and supinator longus, and thence onwards to the bend of the elbow, where it divides into two branches, radial and posterior interosseous.

The **branches** of the musculo-spiral nerve are—

Muscular,	Radial,
Cutaneous,	Posterior interosseous.

The **muscular branches** are distributed to the triceps, anconeus, brachialis anticus, supinator longus, and extensor carpi radialis longior.

The **cutaneous branches** are three in number, internal and two external. The *internal branch* arises from the nerve in the axilla, and piercing the deep fascia in the upper third of the arm on its posterior aspect, communicates with the intercosto-humeral nerve, and is distributed to the integument of the posterior aspect of the upper arm, as far as the olecranon.

The *external cutaneous branches* pass through the substance of the external head of the triceps, and pierce the deep fascia; one, *upper*, near the insertion of the deltoid, the other, *lower*, at about the middle of the upper arm. The *upper branch* follows the course of the cephalic vein, supplying the integument of the outer and fore-part of the upper arm as far as the bend of the elbow. The *lower branch* passes down the outer side of the forearm, reaches the posterior aspect at about its middle, and is continued onwards to the wrist, where it communicates with the posterior branch of the musculo-cutaneous.

The **radial nerve** runs along the radial side of the forearm to the commencement of its lower third; it there passes beneath the tendon of the supinator longus, and, at about two inches above the wrist-joint, pierces the deep fascia and divides into an external and internal branch.

The *external branch*, the smaller of the two, is distributed to the outer border of the thumb, and communicates with the posterior branch of the musculo-cutaneous nerve. The *internal branch* crosses the direction of the extensor tendons of the thumb, and divides into

several filaments for the supply of the ulnar border of the thumb, radial border of the index finger, and adjacent borders of the index and middle finger. It communicates above the wrist with the posterior branch of the musculo - cutaneous nerve, and on the back of the hand forms an arch by joining with the dorsal branch of the ulnar nerve. On the backs of the fingers the digital branches communicate with those of the median nerve.

In the upper third of the forearm the radial nerve lies beneath the border of the supinator longus muscle; in the middle third it is in relation with the radial artery, lying to its outer side; and in the lower third it quits the artery, and passes beneath the tendon of the supinator longus to reach the back of the hand.

The radial nerve is purely cutaneous in its distribution, giving no branches to muscles.

The **posterior interosseous nerve,** somewhat larger than the radial, separates from the latter at the bend of the elbow, pierces the supinator brevis muscle, and emerges from its lower border on the posterior aspect of the forearm, where it divides into branches which supply all the muscles of the posterior aspect of the forearm, with the exception of the anconeus, supinator longus, and extensor

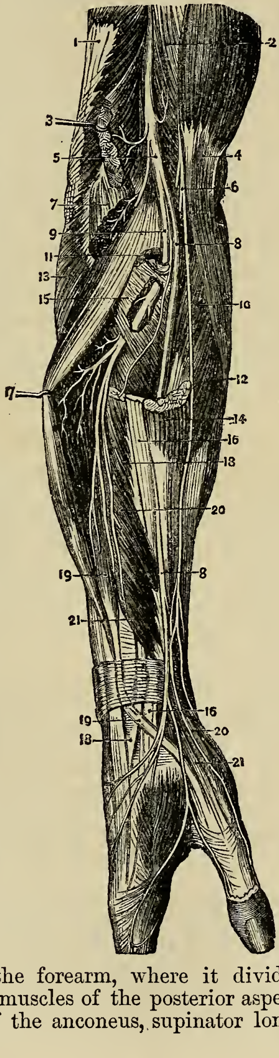


Fig. 309. — Dissection of the musculo-spiral nerve and its branches. 1. Triceps. 2. Brachialis anticus. 3. Supinator longus. 4. Biceps. 5. Musculo - spiral nerve. 6. Musculo-cutaneous nerve. 7. Origin of extensor carpi radialis longior. 8, 8. Radia nerve. 9. Posterior interosseous nerve. 10. Pronator radii teres. 11. Origin of extensor carpi radialis brevior. 12. Flexor carpi radialis. 13. Anconeus. 14. Tendon of supinator longus. 15. Supinator brevis. 16, 16. Tendon of extensor carpi radialis longior. 17. Extensor communis digitorum. 18, 18. Tendon of extensor carpi radialis brevior. 19, 19. Extensor secundi internodii pollicis. 20, 20. Extensor ossis metacarpi pollicis. 21, 21. Extensor primi internodii pollicis.

carpi radialis longior. In passing from the front to the back of the forearm it winds round the outer side of the radius, and does not pass between the two bones as the posterior interosseous artery does. One branch, longer than the rest, descends upon the interosseous membrane to the posterior part of the wrist, and forms a gangliform swelling (a common character of nerves which supply joints), from which numerous filaments are distributed to the wrist-joint.

The **CIRCUMFLEX NERVE** arises from the posterior cord of the brachial plexus in common with the musculo-spiral. It passes downwards over the border of the subscapularis muscle, winds around the neck of the humerus with the posterior circumflex artery, and splits into an upper and lower division; the upper division is continued onwards beneath the deltoid, and distributed to the anterior part of that muscle, some of its branches piercing the muscular fibres and becoming cutaneous. The lower division sends a branch (remarkable for a gangliform swelling) to the teres minor, several branches to the posterior part of the deltoid, and mounting upon the border of that muscle becomes *cutaneous*, supplying the integument over its lower half by means of several filaments. Besides its muscular and cutaneous branches, the trunk of the nerve gives off an *articular* branch, which enters the shoulder-joint at its posterior and under part.

DORSAL NERVES.

The dorsal nerves are twelve in number at each side, the first appearing between the first and second dorsal vertebra, the last between the twelfth dorsal and first lumbar. They are smaller than the lower cervical nerves, diminish gradually in size from the first to the tenth, and then increase to the twelfth. Each nerve, as soon as it has escaped from the intervertebral foramen, separates into an anterior and posterior cord; the anterior cords being the intercostal nerves, the posterior the dorsal branches of the dorsal nerves.

The **dorsal branches** pass directly backwards between the transverse processes of the vertebræ, lying internally to the anterior costo-transverse ligament, and each nerve divides into an *internal* and *external* branch. The *internal branches* diminish in size from the first to the last. The six upper branches pass inwards between the semispinalis dorsi and multifidus spinæ, and, piercing the rhomboid, trapezius, and latissimus dorsi, become cutaneous close to the spinous processes, and are then reflected outwards to supply the integument. The six lower branches are lost in the muscles of the spine.

The *external branches* increase in size from above downwards, and make their appearance in the line of separation between the longissimus dorsi and sacro-lumbalis. The six upper branches are distributed to those muscles and the levatores costarum. The six lower, after supplying the same muscles, pierce the serratus posticus inferior and latissimus dorsi in a line with the angles of the ribs,

and becoming *cutaneous*, are directed downwards and forwards over the side of the trunk.

INTERCOSTAL NERVES.—The *anterior cords* of the dorsal nerves, twelve in number at each side, are the **intercostal nerves.** Each intercostal nerve passes outwards in the intercostal space in company with the intercostal vessels, below which it lies; at the commencement of its course it rests on the external intercostal muscle, further outwards it is placed between the two planes of intercostal muscles; beyond the middle of the rib it enters the substance of the internal intercostal and reaches its inner surface, being in contact with the pleura; finally, at the anterior extremity of the intercostal space, it crosses in front of the triangularis sterni and internal mammary vessels, and piercing the internal intercostal muscle and pectoralis major, is distributed to the integument of the front of the chest and mammary gland, under the name of **anterior cutaneous.** The intercostal nerve, near its origin, sends one or two filaments to the neighbouring dorsal ganglion of the sympathetic, and midway between the vertebral column and sternum, while situated between the intercostal muscles, gives off a **lateral cutaneous branch** which pierces the external intercostal muscle and divides into an interior and posterior twig for the supply of the integument of the side of the thorax.

This description applies in full only to the six upper intercostal nerves; the six lower, with the exception of the last, cross the cartilages of the ribs where the thorax is deficient and take their course between the internal oblique and transversalis muscle to the sheath of the rectus, and, after supplying that muscle, to the linea alba, by the side of which they reach the integument constituting the **anterior cutaneous nerves** of the abdomen.

The first and the last intercostal nerve are exceptions to this general scheme of distribution. The *first* ascends over the first rib to join the brachial plexus, and gives off only a small branch, to take the usual course of the other intercostal nerves. The *last* or *twelfth nerve* lies below the last rib, and after crossing the quadratus lumborum takes its course between the internal oblique and transversalis muscle like the other inferior intercostals. Near its origin it sends a branch, the *dorsi-lumbar*, downwards to join the first lumbar nerve.

The **branches** of the intercostal nerves are—muscular, lateral cutaneous, and anterior cutaneous.

The **muscular branches** are small twigs distributed to the intercostal and neighbouring muscles.

The **lateral cutaneous nerves,** given off from the intercostals at about the middle of the lateral half of the thorax, pierce the external intercostal muscle and pass between the fibres of the serratus magnus above and the obliquus externus below to reach the surface. The lateral cutaneous nerve then divides into an anterior and posterior branch. The *anterior branches* are directed forwards to supply the integument of the antero-lateral aspect of the trunk, some

of the superior branches turning around the inferior border of the pectoralis major to the mammary gland. The *posterior branches*

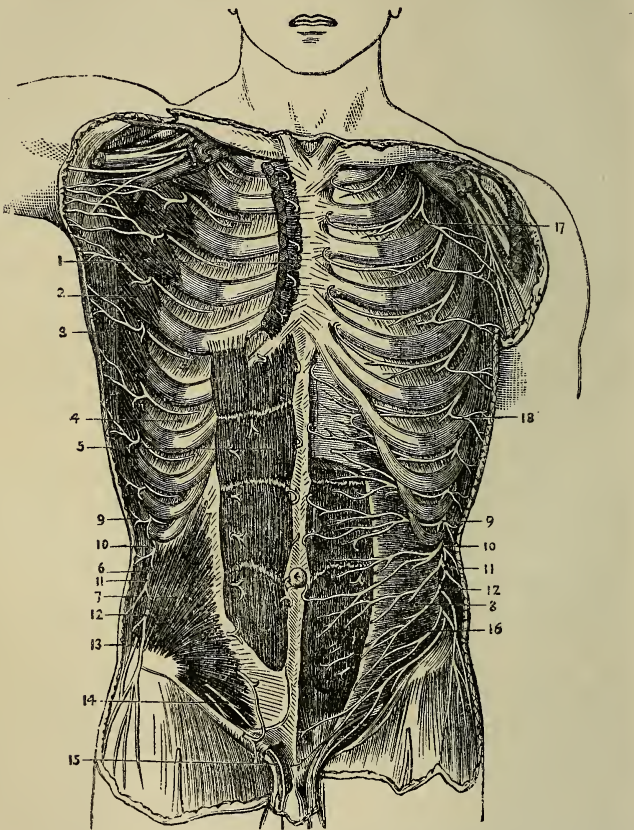


FIG. 310.—The nerves of the abdominal wall. 1. Pectoralis major (cut). 2. Serratus magnus. 3. Latissimus dorsi. 4. Intercostal muscles. 5. Rectus abdominis. 6. Section of obliquus externus. 7. Obliquus internus. 8. Transversalis abdominis. 9, 9. Ninth dorsal nerve. 10, 10. Tenth dorsal nerve. 11, 11. Eleventh dorsal nerve. 12, 12. Twelfth dorsal nerve. 13. Iliac branch of ilio-hypogastric. 14. Hypogastric branch of ilio-hypogastric. 15. Inguinal branch of ilio-inguinal. 16. Ilio-hypogastric and ilio-inguinal nerves. 17. Intercosto-humeral nerve. 18. Lateral cutaneous branch of intercostal nerve.

take their course backwards to supply the integument of the postero-lateral aspect of the trunk, some of the superior turning around the posterior border of the axilla to reach the integument over the lower

part of the scapula and latissimus dorsi ; and that from the third intercostal being distributed to the integument of the axilla and neighbouring part of the arm.

The first intercostal gives off no lateral cutaneous nerve ; the lateral cutaneous branch of the second intercostal nerve will be presently described, under the name of *intercosto-humeral nerve.* The lateral cutaneous branch of the last intercostal nerve pierces the internal and external oblique muscle, crosses the crest of the ilium just behind the tensor vaginæ femoris, and is distributed to the integument of the anterior part of the gluteal region as low down as the trochanter major.

The **anterior cutaneous nerves** are divided according to their position into those of the thorax and those of the abdomen. Having reached the surface they are reflected outwards to supply the integument of the front of the trunk. The anterior cutaneous branches of the third and fourth intercostal nerve are distributed to the mammary gland.

The **intercosto-humeral nerve** is the lateral cutaneous branch of the second intercostal nerve ; after piercing the external intercostal muscle, it passes downwards into the axilla and communicates with a branch of the lesser internal cutaneous nerve of Wrisberg. It then perforates the deep fascia, and is distributed to the integument of the inner and back part of the arm to about the middle, and to the integument covering the lower part of the scapula. On the back of the arm it communicates with the internal cutaneous branch of the musculo-spiral nerve. This nerve sometimes takes the place of the nerve of Wrisberg.

LUMBAR NERVES.

There are five pairs of lumbar nerves, of which the first makes its appearance between the first and second lumbar vertebra ; the last between the fifth lumbar and the base of the sacrum. The **anterior divisions** increase in size from above downwards. They communicate at their origin with the lumbar ganglia of the sympathetic, and pass obliquely outwards behind the psoas magnus, or between its fasciculi, sending twigs to that muscle and to the quadratus lumborum. In this situation each nerve divides into two branches, a superior branch which ascends to form a loop of communication with the nerve above ; and an inferior branch which descends to join in like manner the nerve below. The communications which are thus established constitute the lumbar plexus.

The **posterior divisions** diminish in size from above downwards ; they pass backwards between the transverse processes of the corresponding vertebræ, and each nerve divides into an internal and external branch. The *internal branch*, the smaller of the two, passes inwards to be distributed to the multifidus spinæ and inter-spinales. The *external branches* communicate with each other by several loops, and, after supplying the deeper muscles, pierce the sacro-

lumbalis to reach the integument to which they are distributed. The external branches of the three upper lumbar nerves descend over the posterior part of the crest of the ilium, and are distributed to the integument of the gluteal region.

LUMBAR PLEXUS.—The lumbar plexus is formed by the communications and anastomoses which take place between the anterior divisions of the four upper lumbar nerves, and between the latter and the last dorsal. It is narrow above, increases in breadth

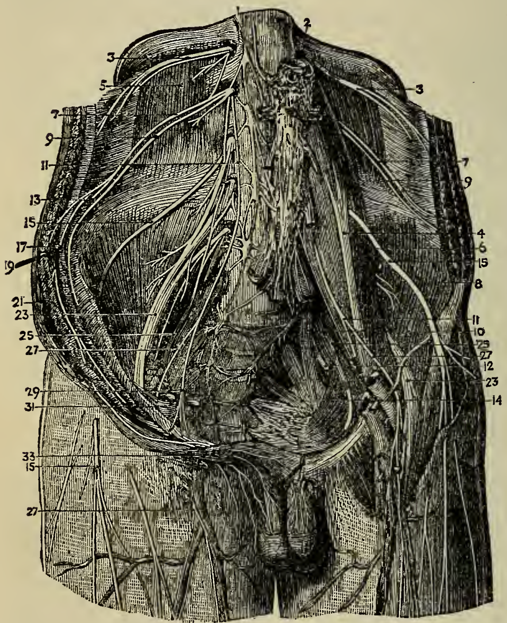


FIG. 311. — Lumbar plexus. 1. Right gangliated cord of sympathetic. 2. Abdominal aorta. 3, 3. Last dorsal nerves. 4. Psoas parvus. 5. Quadratus lumborum. 6. Psoas magnus. 7, 7. Ilio-hypogastric nerves. 8. Iliacus internus. 9, 9. Ilio-inguinal nerve. 10. Lumbo-sacral nerve. 11, 11. Genito-crural nerves. 12. Gluteal nerve. 13. Iliac branch of ilio-hypogastric nerve. 14. Sacral plexus. 15, 15, 15. External cutaneous nerves. 17. Transversalis abdominis. 19. Obliquus internus. 21. Obliquus externus. 23, 23. Anterior crural nerves. 25, 25. Obturator nerves. 27, 27. Crural branch of genito-crural nerve. 29. Genital branch of genito-crural nerve. 31. External iliac artery. 33. External abdominal ring.

inferiorly, and is situated between the transverse processes of the lumbar vertebræ and quadratus lumborum behind, and the psoas magnus muscle in front.

The **branches** of the lumbar plexus are the—

Ilio-hypogastric,	External cutaneous,
Ilio-inguinal,	Obturator,
Genito-crural,	Anterior crural.

The **ILIO-HYPOGASTRIC NERVE** proceeds from the first lumbar nerve, and passes obliquely outwards between the fibres of the psoas magnus and across the quadratus lumborum to about the middle of the crest of the ilium. It then pierces the transversalis

muscle, and between it and the internal oblique divides into its two terminal branches, iliac and hypogastric.

The **iliac branch** pierces the internal and external oblique muscles close to their attachment, and a little behind the middle of the crest of the ilium; it is distributed to the integument of the gluteal region as far down as the upper part of the hip.

The **hypogastric branch** continues its course onwards, piercing first the internal oblique, and just above the external abdominal ring the aponeurosis of the external oblique. It is distributed to the integument of the hypogastric region and mons pubis.

The **ILIO-INGUINAL NERVE**, smaller than the preceding, also arises from the first lumbar nerve. It passes obliquely downwards and outwards below the ilio-hypogastric nerve, and crosses the quadratus lumborum and iliacus muscle to the anterior part of the crest of the ilium; it then pierces the transversalis muscle, and between that muscle and the obliquus internus communicates with the hypogastric nerve. It next pierces the obliquus internus, and following the course of the spermatic cord, escapes at the external abdominal ring to be distributed to the scrotum and to the integument of the upper part of the thigh, internally to the saphenous opening; and in the female to that of the pudendum.

The **GENITO-CRURAL NERVE** proceeds from the second lumbar and by a few filaments from the loop between it and the first. It traverses the psoas magnus from behind forwards, and runs down the anterior surface of that muscle, lying beneath its fascia, to near Poupart's ligament, where it divides into a genital and a crural branch.

The **genital branch** crosses the external iliac artery to the internal abdominal ring, and descends along the spermatic canal, lying behind the cord, to the scrotum, where it distributes twigs to the spermatic cord and cremaster muscle. In the female it gives twigs to the round ligament and external labium. At the internal abdominal ring this nerve sends off a branch, which, after supplying the lower border of the internal oblique and transversalis, is lost in the integument of the groin.

The **crural branch**, the most external of the two, descends along the outer border of the external iliac artery, and, crossing the origin of the deep circumflex iliac artery, enters the sheath of the femoral vessels in front of the femoral artery. It pierces the sheath below Poupart's ligament, and is distributed to the integument of the anterior aspect of the thigh as far as its middle. This nerve communicates with the middle cutaneous branch of the anterior crural nerve, and is often very small.

The **EXTERNAL CUTANEOUS NERVE** proceeds from the second lumbar, and from the loop between it and the third. It pierces the posterior fibres of the psoas muscle, and crossing the iliacus on the iliac fascia, to the anterior superior spinous process of the ilium, passes into the thigh, beneath Poupart's ligament, where it divides into two branches, anterior and posterior.

The **posterior branch** crosses the tensor vaginæ femoris muscle to the outer and posterior side of the thigh, and supplies the integument in that region.

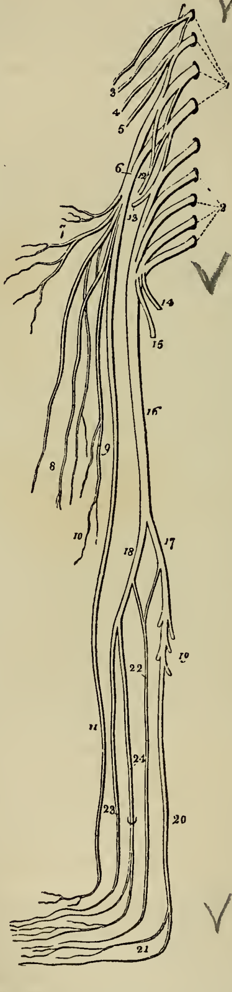


Fig. 312. — A diagram showing the lumbar and sacral plexuses, with the nerves of the lower extremity. 1. The first four lumbar nerves; which, with a branch from the last dorsal, constitute the lumbar plexus. 2. The four upper sacral nerves; which, with the last lumbar, form the sacral plexus. 3. The ilio-hypogastric and ilio-inguinal nerves. 4. Genito-crural nerve. 5. External cutaneous nerve. 6. Anterior crural nerve. 7. Its muscular branches. 8. Middle cutaneous branches. 9, 10. Internal cutaneous branches. 11. The long or internal saphenous. 12. Obturator nerve. 13. Gluteal nerve, a branch of the lumbo-sacral. 14. Internal pudic nerve. 15. Lesser ischiatic nerve. 16. Greater ischiatic nerve. 17. Internal popliteal nerve. 18. External popliteal nerve. 19. Muscular branches. 20. Posterior tibial nerve, dividing at 21 into the two plantar nerves. 22. External saphenous nerve. 23. Anterior tibial nerve. 24. Musculo-cutaneous nerve, piercing the deep fascia, and dividing into two cutaneous branches for the supply of the dorsum of the foot.

The **anterior nerve,** after passing for three or four inches down the thigh in a sheath formed by the fascia lata, becomes superficial, and divides into two branches, which are distributed to the integument of the outer border of the thigh, and to the articulation of the knee.

The **OBTURATOR NERVE** is formed by a branch from the third, and another from the fourth lumbar nerve, and is distributed to the obturator externus and adductor muscles of the thigh, the hip and knee joint, the femoral and popliteal artery, and sometimes to the integument of the upper and inner part of the leg. From its origin it takes its course among the fibres of the psoas muscle, through the angle of bifurcation of the common iliac vessels, and along the inner border of the brim of the pelvis, to the obturator foramen, where it joins the obturator artery. Having escaped from the pelvis it divides into an anterior and posterior branch.

The **anterior branch** passes downwards in front of the adductor brevis, supplies that muscle together with the pectineus, gracilis, and adductor longus, and at the lower border of the latter unites with the internal cutaneous and

long saphenous nerve, to form a plexus. It then passes onwards to the femoral artery, to which it distributes filaments. In its course this nerve gives off an *articular* branch to the hip-joint; and a *cutaneous* branch, which pierces the fascia lata at the knee, communicates with the long saphenous nerve, and is distributed to the integument of the inner side of the leg as far as its middle. The cutaneous branch is often wanting, its place being supplied by the internal cutaneous nerve, and sometimes by the accessory obturator.

The **posterior branch** pierces the obturator externus muscle, to which and to the adductor magnus it distributes branches; it also gives off an *articular branch* which pierces the adductor magnus muscle, and accompanies the popliteal artery to the knee-joint.

The **accessory obturator nerve**, small and inconstant, is a high division of the obturator, being sometimes derived from it near its origin, and sometimes by separate filaments from the third and fourth lumbar nerve. It passes down the inner border of the psoas muscle, crosses the os pubis, and dips beneath the pectineus, where it divides into branches. One of its branches is distributed to the pectineus, another supplies the hip-joint, while a third communicates with the anterior branch of the obturator nerve, and when of large size constitutes its *cutaneous* branch. As already stated, the existence of the accessory obturator nerve is uncertain.

The **ANTERIOR CRURAL** or **FEMORAL NERVE** is the largest of the divisions of the lumbar plexus; it is formed by the union of branches from the second, third, and fourth lumbar nerve, and is distributed to the integument of the front and inner side of the thigh, leg, and foot, to all the muscles of the front of the thigh (excepting one), to the iliacus, pectineus, femoral artery, and knee-joint. Emerging from beneath the psoas, the nerve passes downwards in the groove between that muscle and the iliacus, and beneath Poupart's ligament into the thigh, where it spreads out and divides into numerous branches. At Poupart's ligament it is separated from the femoral artery by the breadth of the psoas muscle, which at this point is scarcely more than half an inch in diameter, and by the iliac fascia, beneath which it lies.

Branches.—Within the pelvis, the anterior crural nerve gives off three or four twigs to the iliacus muscle, and a *branch to the femoral artery.* The latter divides into filaments which entwine about the artery, and follow its course downwards in the thigh. Below Poupart's ligament the crural nerve becomes flattened out, and divides into numerous branches, which may be arranged into two principal groups, superficial and deep. The separate branches of these groups are as follows :—

Superficial.	**Deep.**
Middle cutaneous,	Muscular,
Internal cutaneous,	Articular.
Long or internal saphenous.	

The **middle cutaneous nerve** pierces the fascia lata at about three inches below Poupart's ligament, and divides into two branches, which pass down the inner and front part of the thigh, and are distributed to the integument as low as the knee-joint. At its upper part the external branch communicates with the crural branch of the genito-crural nerve; and below, the internal branch communicates with the internal cutaneous. One or both of these branches sometimes pierce the sartorius muscle.

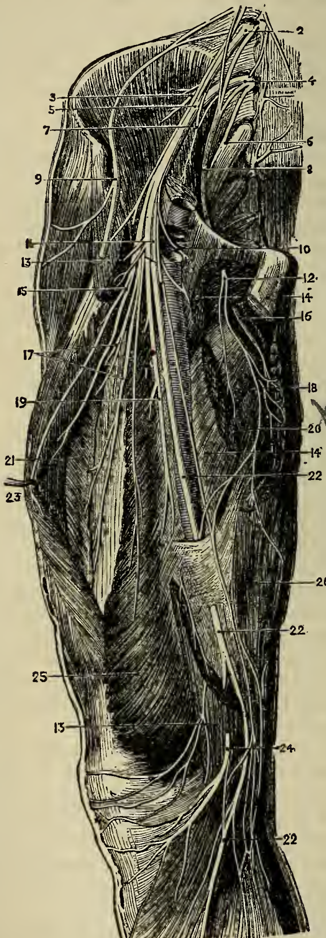


FIG. 313.—Nerves of the thigh. 1. Gangliated cord of sympathetic. 2. Third lumbar nerve. 3. Branches to iliacus internus. 4. Fourth lumbar nerve. 5. Anterior crural nerve. 6. Lumbo-sacral nerve. 7. Branch to psoas. 8. Obturator nerve. 9. External cutaneous nerve (cut). 10. Nerve to pectineus. 11. Superficial division of anterior crural nerve (cut). 12. Superficial division of obturator nerve. 13, 13. Sartorius muscle. 14, 14. Adductor longus. 15. Branch to rectus. 16. Deep division of obturator nerve. 17. Branches to vastus internus and crureus. 18. Adductor brevis. 19. Branch to vastus internus. 20. Adductor magnus. 21. Vastus externus. 22, 22. Internal saphenous nerve. 23. Rectus femoris. 24. Patellar branch of saphenous nerve. 25. Vastus internus. 26. Gracilis.

The **internal cutaneous nerve** passes inwards in front of the sheath of the femoral artery, and divides into an *anterior* and an *inner* branch. Previously to its division it gives off three cutaneous filaments, which pierce the fascia near the internal saphena vein, and following the course of that vessel, are distributed to the integument of the inner side of the thigh as low down as the knee. The uppermost of these filaments passes through the saphenous opening, the middle becomes subcutaneous at about the middle of the thigh, and the lowest pierces the fascia at its lower third.

The *anterior branch* passes down the inner side of the thigh, and

pierces the fascia at its lower third, near the internal saphena vein. It then divides into two twigs, one of which continues onwards to the inner side of the knee; while the other curves outwards to its outer side, communicating in its course with a branch of the long saphenous nerve.

The *inner* branch descends along the inner and posterior border of the sartorius muscle to the knee, where it pierces the fascia lata, and gives off several cutaneous twigs. It then sends a small branch of communication to the long saphenous nerve, and passes downwards along the inner side of the leg, to which it is distributed. While beneath the fascia lata it aids in the formation of a plexus by uniting with branches of the long saphenous nerve and descending branch of the obturator. When the latter is large the inner branch of the internal cutaneous nerve is small, and may terminate in the plexus, or merely give off a few cutaneous filaments.

The **long** or **internal saphenous nerve** inclines inwards to the sheath of the femoral vessels, and passes downwards in front of the sheath and beneath the aponeurotic expansion which covers the sheath, to the opening in the adductor magnus. It then quits the femoral vessels, and continuing to descend, passes between the tendons of the sartorius and gracilis, and reaches the internal saphena vein. By the side of the latter it passes down the inner side of the leg, in front of the inner ankle, and along the inner side of the foot as far as the great toe, being distributed to the integument in its course.

The branches of the long saphenous nerve in the thigh are—one or two to join the plexus formed by the obturator and internal cutaneous nerve; and a large branch, the *cutaneus patellæ*, which pierces the sartorius and fascia lata at the inner side of the knee, and divides into many twigs, which are distributed to the integument of the front of the knee. Above the patella this branch communicates with the anterior branch of the internal cutaneous nerve, and with the terminal twigs of the middle, and external cutaneous. Below the patella it communicates with other branches of the long saphenous; the whole of these communications constituting a kind of plexus (plexus patellæ).

The branches of the long saphenous nerve below the knee are distributed to the integument of the front and inner side of the leg. By one of these branches it communicates with the cutaneous branch of the obturator nerve.

The **muscular branches** of the anterior crural nerve supply all the muscles of the front of the thigh (with the exception of the tensor vaginæ femoris, which obtains its nerve from the superior gluteal) and the pectineus. The branch to the *pectineus* passes behind the sheath of the femoral vessels; the branches to the *sartorius*, three or four in number, *arise* with the cutaneous nerves, and sometimes are supplied by the latter. The branch to the *rectus* enters the deep surface of that muscle. The branch to the *vastus externus* follows the course of the descending branch of the

external circumflex artery; the branch to the *crureus* passes directly to that muscle; and the branch to the *vastus internus*, remarkable for its length, descends by the side of the sheath of the femoral vessels.

The **articular branches** are distributed to the knee-joint; one enters the joint at its outer side, being derived from the nerve of the vastus externus; the other, proceeding from the nerve of the vastus internus, descends with the anastomotica magna to a level with the joint, and then pierces the capsular ligament.

The **LUMBO-SACRAL NERVE.**—The anterior division of the fifth lumbar nerve, conjoined with a branch from the fourth, constitutes the lumbo-sacral nerve, which descends over the base of the sacrum into the pelvis, and assists in forming the sacral plexus. Immediately before it joins the first sacral, it gives off the superior gluteal nerve, but this nerve is, notwithstanding, usually described as a branch of the sacral plexus.

The connection of the nerves of the plexus with the anterior divisions of the lumbar nerves, may be most simply expressed in a tabular form, as follows:—

Ilio-hypogastric	1.
Ilio-inguinal	1.
Genito-crural	1, 2.
External cutaneous	2, 3.
Anterior crural	2, 3, 4.
Obturator	3, 4.
Lumbo-sacral	4, 5.

SACRAL NERVES.

There are five pairs of sacral nerves; the first four escape from the vertebral canal through the sacral foramina, the last between the sacrum and coccyx. The *posterior sacral nerves* are small, and diminish in size from above downwards; they communicate with each other by means of anastomosing loops immediately after their escape from the posterior sacral foramina, and divide like the other spinal nerves into external and internal branches. The external branches pierce the gluteus maximus, to which they give filaments, and are distributed to the integument of the posterior part of the gluteal region. The internal branches supply the multifidus spinæ muscle and the integument over the sacrum and coccyx.

The **anterior sacral nerves** diminish in size from above downwards; the *first* is large, and unites with the lumbo-sacral nerve; the *second*, of equal size, unites with the first; and the *third*, scarcely one-fourth so large as the second, joins with the two preceding nerves in the formation of the sacral plexus.

The **fourth sacral nerve** divides into two branches, one of which assists in forming the sacral plexus, the other separates into three branches: a *communicating branch*, to unite with the fifth sacral

nerve; a *visceral branch*, to join with the hypogastric plexus and supply the bladder and prostate gland, and in the female the vagina; and a *muscular branch*, which sends filaments to the levator

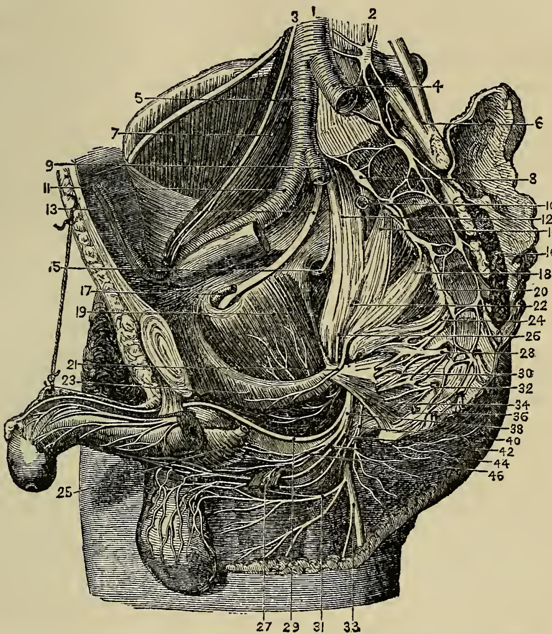


FIG. 314.—Side view of the nerves of the pelvis, the viscera having been removed 1. Abdominal aorta. 2. Gangliated cord of sympathetic (left side). 3. Genito crural nerve. 4. Left common iliac artery. 5. Right common iliac artery. 6 Left lumbo-sacral cord. 7. Psoas muscle. 8. Gangliated cord of sympathetic (right side). 9. Internal iliac artery (cut). 10. Gluteal artery (cut). 11. Right external iliac artery. 12. Right lumbo-sacral nerve. 13. Obturator nerve. 14. First sacral nerve. 15. Gluteal nerve. 16. Pyriformis of left side (cut). 17. Obturator artery. 18. Second sacral nerve. 19. Obturator internus. 20. Pyriformis of right side. 21. Nerve to levator ani. 22. Sacral plexus. 23. Levator ani (cut). 24. Third sacral nerve. 25. Bulb of urethra covered by accelerator urinæ. 26. Nerve to obturator internus. 27. Transversus perinæi (cut). 28. Fourth sacral nerve. 29. Dorsal nerve of penis. 30. Visceral branches (cut). 31. Inferior pudendal nerve. 32. Fifth sacral nerve. 33. Small sciatic nerve. 34. Coccygeus muscle. 36. Sixth or coccygeal nerve. 38. Internal pudic nerve. 40. Inferior hæmorrhoidal nerve. 42. Posterior superficial perineal nerve. 44. Anterior superficial perineal nerve. 46. Deep perineal nerves to bulb and muscles.

ani and coccygeus, and a *hæmorrhoidal branch* to the sphincter ani and integument behind the anus.

The **fifth sacral nerve**, issuing from between the sacrum and coccyx, pierces the coccygeus muscle, and receives the communicating branch from the fourth; it then communicates with the

coccygeal nerve, and piercing the coccygeus a second time, is distributed to the integument over the dorsal surface of the coccyx.

The **coccygeal nerve** pierces the coccygeus muscle, and unites with the fifth sacral nerve, in which it is lost.

Each of the anterior cords of the sacral nerves communicates with the sympathetic at its point of escape from the sacral canal.

SACRAL PLEXUS.—The sacral plexus is formed by the union of the lumbo-sacral and the anterior cords of the three upper sacral nerves and one-half the fourth. The plexus is triangular in form, its base corresponding with the whole length of the sacrum, and its apex with the lower part of the great sacro-ischiatic foramen. It is in relation behind with the pyriformis muscle, and in front with the pelvic fascia, which separates it from the internal iliac vessels and the viscera of the pelvis.

The **branches** of the sacral plexus are—

Visceral,	Pudic,
Muscular,	Lesser ischiatic,
Superior gluteal,	Greater ischiatic.

The **visceral nerves** are three or four large branches derived from the fourth and fifth sacral nerves: they ascend by the side of the rectum and bladder; in the female by the side of the rectum, vagina, uterus, and bladder; and interlace with branches of the hypogastric plexus, sending in their course numerous filaments to the pelvic viscera.

The **muscular branches** are one or two twigs to the *levator ani;* an *obturator branch*, which curves around the spine of the ischium to reach the internal surface of the obturator internus muscle; two twigs to the *pyriformis;* a branch to the *gemellus superior;* and a branch of moderate size, which descends between the gemelli muscles and the ischium, and is distributed to the *gemellus inferior*, *quadratus femoris*, and capsule of the *hip-joint*.

The **SUPERIOR GLUTEAL NERVE** arises from the lumbo-sacral near its junction with the first sacral nerve; it passes out of the pelvis with the gluteal artery, through the great sacro-ischiatic foramen, and divides into a superior and an inferior branch.

The **superior branch** follows the direction of the superior curved line of the ilium, accompanying the deep superior branch of the gluteal artery, and sends filaments to the gluteus medius and minimus.

The **inferior branch** passes obliquely downwards and forwards between the gluteus medius and minimus, distributing numerous filaments to both, and terminates in the tensor vaginæ femoris muscle.

The **PUDIC NERVE** arises from the lower part of the sacral plexus and passes out of the pelvis through the great sacro-ischiatic foramen below the pyriformis muscle. It crosses the spine of the ischium, and re-entering the pelvis through the lesser sacro-ischiatic foramen, accompanies the internal pudic artery along the outer wall

of the ischio-rectal fossa, lying inferiorly to the artery and enclosed in the same sheath. Near its origin it gives off the *inferior hæmorrhoidal* nerve, and in the ischio-rectal fossa divides into a superior and inferior branch.

The **inferior hæmorrhoidal nerve**, often a branch of the sacral plexus, passes through the lesser sacro-ischiatic foramen, and descends to the termination of the rectum to be distributed to the sphincter ani and integument.

The **dorsalis penis nerve**, the superior division of the internal pudic, ascends along the posterior surface of the ramus of the ischium, pierces the triangular ligament, and accompanies the arteria dorsalis penis to the glans, to which it is distributed. At the root of the penis the nerve gives off a cutaneous branch which runs along the side of the organ, gives filaments to the corpus cavernosum, and with its fellow of the opposite side supplies the integument of the upper two-thirds of the penis.

The **perineal nerve**, or inferior terminal branch, larger than the preceding, pursues the course of the superficial perineal artery in the perineum and divides into cutaneous and muscular branches.

The **cutaneous branches** (superficial perineal), two in number, *posterior* and *anterior*, enter the ischio-rectal fossa and pass forward with the superficial perineal artery to be distributed to the integument of the perineum, scrotum, and under part of the penis. The *posterior* superficial perineal nerve sends a few filaments to the integument of the anus and sphincter ani; while the *anterior* gives off one or two twigs to the levator ani.

The **muscular branches** proceed from a single trunk, which passes inwards behind the transversus perinei muscle; they are distributed to the transversus perinei, accelerator urinæ, and erector penis. The perineal nerve also sends two or three filaments to the *corpus spongiosum.*

In the female the pudic nerve is distributed to the parts analogous to those of the male. The *superior branch* supplies the clitoris; the *inferior* the vulva and perineum.

The **LESSER ISCHIATIC NERVE** passes out of the pelvis through the great sacro-ischiatic foramen below the pyriformis muscle, and continues its course downwards through the thigh to the lower part of the popliteal region, where it pierces the fascia and becomes subcutaneous. It then accompanies the external saphena vein to the lower part of the leg, and communicates with the external saphenous nerve.

The branches of the lesser ischiatic nerve are muscular and cutaneous. The *muscular* or *inferior gluteal* are several large branches distributed to the gluteus maximus.

The **cutaneous branches** are divisible into external, internal, and middle. The *external cutaneous branches* are several filaments which turn around the lower border of the gluteus maximus, and are distributed to the integument over the hip and outer side of the thigh. The *internal cutaneous branches* are distributed to the integu-

ment of the upper and inner part of the thigh. One of these, larger than the rest, **inferior pudendal**, curves around the tuberosity of the ischium, pierces the fascia lata near the ramus of that bone, and, after communicating with one of the superficial perineal nerves, is distributed to the integument of the scrotum and penis. The *middle cutaneous branches*, two or three in number, are derived from the lesser ischiatic in its course down the thigh, and are distributed to the integument.

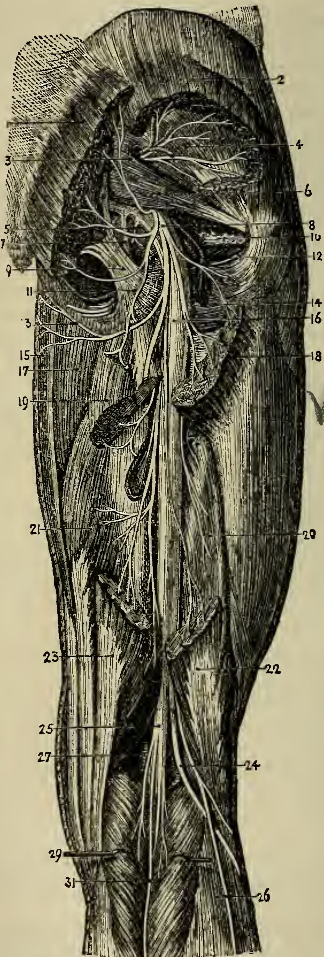


Fig. 315. — Dissection of the buttock and back of the thigh. 1. Gluteus maximus. 2. Gluteus medius. 3. Gluteal artery and nerve. 4. Gluteus minimus. 5. Nerve to obturator internus. 6. Pyriformis. 7. Pudic nerve. 8. Small sciatic nerve. 9. Great sacro-sciatic ligament. 10. Obturator internus and gemelli. 11. Inferior gluteal nerve from small sciatic. 12. Tendon of obturator externus. 13. Inferior pudendal nerve. 14. Quadratus femoris. 15. Gracilis. 16. Great sciatic nerve. 17. Adductor magnus. 18. Insertion of gluteus maximus. 19. United origins of semitendinosus and biceps. 20. Short head of biceps. 21. Semi-membranosus. 22. Tendon of biceps. 23. Tendon of semitendinosus. 24. External popliteal nerve. 25. Internal popliteal nerve. 26. Communicans peronei nerve. 27. Popliteal artery. 29. Gastrocnemius. 31. Communicans poplitei nerve.

The **GREAT ISCHIATIC NERVE** is the largest nervous cord in the body; it is formed by the sacral plexus, or rather is a prolongation of the plexus, and at its exit from the great sacro-ischiatic foramen beneath the pyriformis muscle measures three-quarters of an inch in breadth. It descends through the middle of the space between the trochanter major and tuberosity of the ischium, and along the posterior part of the thigh to its lower third, where it divides into two large terminal branches, internal and external popliteal. This division sometimes takes place at the plexus, and the two nerves descend

side by side; occasionally they are separated at their commencement by a part or by the whole of the pyriformis muscle. The nerve in its course down the thigh rests on the gemellus superior, tendon of the obturator internus, gemellus inferior, quadratus femoris, and adductor magnus, and is covered in by the gluteus maximus and biceps.

The **branches** of the great ischiatic nerve, previously to its division, are, muscular and articular.

The **muscular branches** are given off from the upper part of the nerve and supply both heads of the biceps, the semi-tendinosus, semi-membranosus, and adductor magnus.

The **articular branch** descends to the upper part of the external condyle of the femur, and divides into filaments, which are distributed to the fibrous capsule and synovial membrane of the knee-joint.

The **INTERNAL POPLITEAL NERVE** passes through the middle of the popliteal space, from the division of the great ischiatic nerve to the lower border of the popliteus muscle, accompanies the artery beneath the arch of the soleus, and becomes the posterior tibial nerve. It is superficial in the whole of its course, and lies externally to the vein and artery.

The **branches** of the internal popliteal nerve are—muscular or sural, articular, and a cutaneous branch, the external saphenous.

The **muscular branches**, of considerable size, and four or five in number, are distributed to the two heads of the gastrocnemius, to the soleus, plantaris, and popliteus.

The **articular branches**, two or three in number, supply the knee-joint, two of the twigs accompanying the internal articular arteries.

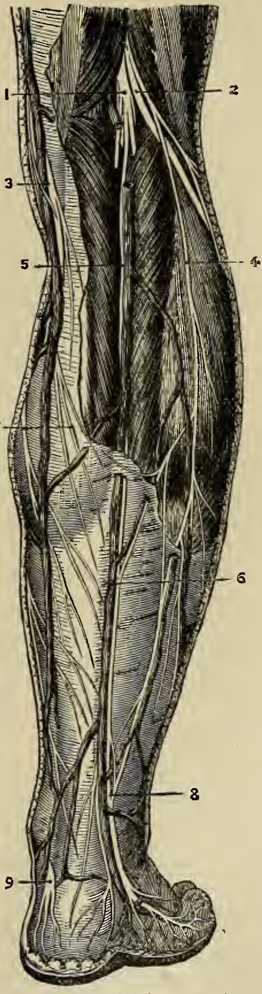


FIG. 316.—Superficial nerves of the back of the leg. 1. Internal popliteal nerve. 2. External popliteal nerve. 3. Internal saphena vein. 4. Nervus communicans peronei. 5. Nervus communicans poplitei. 6. External saphena vein. 7. Internal saphenous nerve. 8. External saphenous nerve. 9. Posterior tibial nerve.

The **external** or **short saphenous nerve** (communicans poplitei, vel tibialis) proceeds from the middle of the internal popliteal, and descends in the groove between the two bellies of the gastrocnemius muscle to the middle of the leg; it then pierces the fascia, and, after receiving the communicans peronei, comes into relation with the external saphena vein, and follows the course of that vein to the outer ankle, to which, and to the integument of the heel and outer side of the foot (cutaneous dorsi pedis externus), it distributes branches.

The **POSTERIOR TIBIAL NERVE** is continued along the posterior aspect of the leg from the lower border of the popliteus muscle to the posterior part of the inner ankle, where it divides into the internal and external plantar nerve. In the upper part of its course it lies to the inner side of the posterior tibial artery; it then becomes placed superficially to that vessel, and at the ankle is situated to its outer side; in the lower third of the leg it lies parallel with the inner border of the tendo-Achillis.

The **branches** of the posterior tibial nerve are—three or four *muscular* twigs to the deep muscles of the posterior aspect of the leg, the branch to the flexor longus pollicis accompanies the nutrient artery of the fibula; one or two filaments which entwine around the artery and then terminate in the integument; and a *plantar cutaneous branch* which pierces the internal annular ligament, and is distributed to the integument of the heel and inner border of the sole of the foot.

The **INTERNAL PLANTAR NERVE**, larger than the external, crosses the posterior tibial vessels to enter the sole of the foot, and becomes placed between the abductor pollicis and flexor brevis digitorum; it then enters the sheath of the latter muscle, and divides opposite the base of the metatarsal bones into three digital branches; *one* to supply the adjacent sides of the great and second toe; the *second*, the adjacent sides of the second and third toe; the *third*, the corresponding sides of the third and fourth toe. This distribution is precisely similar to that of the digital branches of the median nerve in the hand.

In its course the internal plantar nerve gives off *cutaneous branches* to the integument of the inner side and sole of the foot; *muscular* branches to the muscles forming the inner and middle group of the sole; a *digital* branch to the inner border of the great toe; and *articular* branches to the articulations of the tarsal and metatarsal bones.

The **EXTERNAL PLANTAR NERVE**, the smaller of the two, follows the course of the external plantar artery to the outer border of the musculus accessorius, beneath which it sends several deep branches to supply the adductor pollicis, interossei, transversus pedis, and the articulations of the tarsal and metatarsal bones. It then gives branches to the integument of the outer border and sole of the foot, and sends forward two digital branches to supply the little toe and half the next. Its distribution to both skin and muscles corre-

sponds very closely with that of the ulnar nerve in the hand, but, there is this noteworthy difference, that the ulnar supplies half the flexor brevis pollicis, but the external plantar gives no branch to the corresponding muscle in the foot.

The **EXTERNAL POPLITEAL NERVE** (peroneal nerve), one-half smaller than the internal, passes downwards by the side of the tendon of the biceps, and crosses the inner head of the gastrocnemius and the head of the soleus, to the neck of the fibula, it then pierces the peroneus longus muscle, and divides into two branches, anterior tibial and musculo-cutaneous.

The **branches** of the external popliteal nerve are—communicans peronei, cutaneous, and articular.

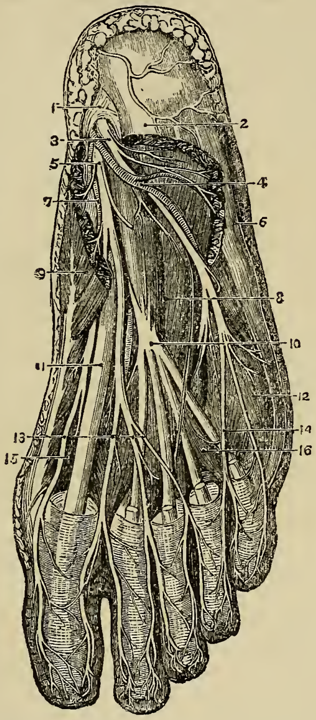


FIG. 317.—Second stage of dissection of sole of foot. 1. Internal annular ligament. 2. Flexor brevis digitorum (cut). 3. External plantar nerve. 4. External plantar artery. 5. Internal plantar nerve. 6. Abductor minimi digiti. 7. Internal plantar artery. 8. Accessorius muscle. 9. Abductor pollicis. 10. Flexor longus digitorum. 11. Flexor longus pollicis. 12. Flexor brevis minimi digiti. 13. Digital branches of internal plantar nerve. 14. Digital branches of external plantar nerve. 15. Flexor brevis pollicis. 16. One of the lumbricales.

The **communicans peronei,** proceeding from the external popliteal near the head of the fibula, crosses the external origin of the gastrocnemius muscle, and, piercing the deep fascia, descends to the middle of the leg, where it joins the external saphenous nerve. It gives off one or two cutaneous filaments in its course.

The **cutaneous** branch passes down the outer side of the leg, supplying the integument.

The **articular** branches follow the external articular arteries to the knee-joint.

The **ANTERIOR TIBIAL NERVE** commences at the bifurcation of the external popliteal on the neck of the fibula, and passes beneath the upper part of the extensor longus digitorum, to reach the outer side of the anterior tibial artery, just as that vessel has emerged through the opening in the interosseous membrane. It

descends the leg with the artery, lying at first to its outer side, then in front of it, and near the ankle becoming again placed to its outer side. Reaching the ankle it passes beneath the annular ligament, accompanies the dorsalis pedis artery, supplies the adjacent sides of the great and second toe, and communicates with the internal division of the musculo-cutaneous nerve.

The **branches** given off by the anterior tibial nerve are—*muscular* to the muscles in its course; and at the ankle a *tarsal* branch which may be considered as one of the terminal divisions of the nerve. This branch passes outwards upon the dorsum of the foot, becomes ganglionic like the posterior interosseous nerve at the wrist, and supplies the extensor brevis digitorum muscle and the articulations of the tarsus and metatarsus.

The **MUSCULO-CUTANEOUS NERVE** passes downwards along the fibula, in the substance of the peroneus longus; it then gets between the peroneus longus and brevis, next between the peronei and extensor longus digitorum, and at the lower third of the leg pierces the deep fascia, and divides into the internal and external cutaneous nerves of the foot. In its course it gives off several branches to the peronei muscles.

The **internal branch**, the smaller of the two, is distributed to the inner side of the foot and great toe, and communicates with the anterior tibial and internal saphenous. The **external**, or larger branch, supplies the adjacent sides of the second and third, third and fourth, and fourth and fifth toes, and communicates with the external saphenous.

SYMPATHETIC NERVES.

The *sympathetic* consists of a vertebral and prevertebral portion. The *vertebral portion* is composed of a series of ganglia united by a longitudinal cord; it descends along each side of the vertebral column from the head to the coccyx, communicates with the cranial and spinal nerves, and distributes branches to the internal organs and viscera. The *prevertebral portion* is that part of the sympathetic which appertains to the viscera, comprising the numerous ganglia and plexuses of the head, chest, abdomen, and pelvis.

The sympathetic nerve communicates with the cerebro-spinal nerves immediately at their exit from the cranium and vertebral canal. With the fourth and sixth nerve, however, it unites in the cavernous sinus; with the olfactory in the nose; and with the auditory in the meatus auditorius internus.

The branches of distribution accompany the arteries which supply the different organs, and form communications around them which are called *plexuses*, and take the name of the artery with which they are associated; thus we have the mesenteric plexus, hepatic plexus, and splenic plexus.

It is called the *ganglionic nerve* from being constituted of a number of *ganglia;* and from the constant disposition which it

evinces in its distribution to communicate and form small knots or ganglia.

The chief sympathetic ganglia in the head are four in number; namely, the ophthalmic or lenticular, the spheno-palatine or Meckel's, the otic or Arnold's, and the submaxillary; three in the neck, superior, middle, and inferior cervical; twelve in the dorsal region; four in the lumbar region; and four or five in the sacral region.

Each ganglion may be considered as a *distinct centre*, receiving and giving branches in four different directions, viz., *superior* or *ascending*, to communicate with the ganglion above; *inferior* or *descending*, to communicate with the ganglion below; *external*, to communicate with the spinal nerves; and *internal*, to communicate with the sympathetic filaments of the opposite side, and be distributed to the viscera.

As regards the spinal nerves it receives as well as gives, the white fibres of the sympathetic being derived from the cerebro-spinal nerves.

CRANIAL PORTION OF THE SYMPATHETIC NERVE.

Cranial Ganglia.

Ophthalmic, or lenticular ganglion,
Spheno-palatine, or Meckel's ganglion,
Otic, or Arnold's ganglion,
Submaxillary ganglion.

The **OPHTHALMIC GANGLION** (*ciliary; lenticular*) is a small quadrangular and flattened ganglion situated within the orbit, between the optic nerve and external rectus muscle; it is in close relation with the optic nerve and generally with the ophthalmic artery; and is surrounded by adipose tissue, which renders its dissection somewhat difficult. It is of a reddish-grey colour, like other sympathetic ganglia.

Its **branches of distribution** are the *short ciliary* nerves, which arise from its anterior angles in two groups; the upper group consisting of about four filaments; the lower, of five or six. They accompany the ciliary arteries in a waving course, and divide into filaments which pierce the sclerotic around the optic nerve to supply the tunics of the eyeball, the greater number of them being traceable to the iris and ciliary processes.

Its **branches of communication** are three: one the *long root*, proceeds from the *nasal* branch of the ophthalmic nerve and joins its superior angle; a short and thick branch, the *short root*, from the inferior division of the third nerve to its inferior angle; and a slender filament, the *sympathetic root*, from the cavernous plexus, which accompanies the long root to the ganglion. Occasionally the ophthalmic ganglion receives also a filament of communication from the spheno-palatine ganglion; and sometimes from the abducens nerve.

The **SPHENO-PALATINE GANGLION** (Meckel's), the largest of the cranial ganglia of the sympathetic, is situated in the spheno-maxillary fossa, a little below the superior maxillary nerve. It is of small size, of a reddish-grey colour, and triangular in shape; and is placed on the posterior part of the spheno-palatine nerves which it only partially involves. Its branches are divisible into four groups: ascending, descending, internal, and posterior.

The **ascending** branches are three or four small filaments which are distributed to the periosteum of the orbit. One of these branches

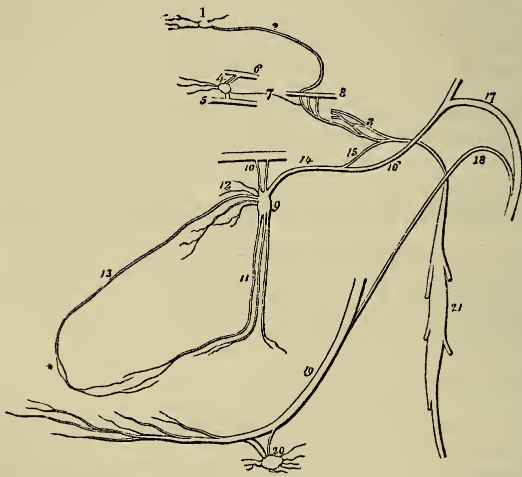


FIG. 318.—Cranial ganglia of the sympathetic nerve. 1. Ganglion of Ribes. 2. Filament by which it communicates with the carotid plexus (3). 4. Ophthalmic or lenticular ganglion, giving off ciliary branches. 5. Part of the inferior division of the third nerve communicating with the ganglion by means of a short thick branch (short root). 6. Part of the nasal nerve, connected with the ganglion by means of a longer branch (long root). 7. A slender filament (the sympathetic root) sent directly backwards from the ganglion to the carotid plexus. 8. Part of the sixth nerve in the cavernous sinus, receiving two branches from the carotid plexus. 9. Meckel's ganglion (spheno-palatine). 10. Spheno-palatine nerves. 11. Descending palatine branches. 12. Its internal or nasal branches. 13. Naso-palatine branch, one of the nasal branches. 14. Posterior branch of the ganglion, the Vidian nerve. 15. Its carotid branch (n. petrosus profundus), communicating with the carotid plexus. 16. Its petrosal branch (n. petrosus superficialis major), joining the intumescentia gangliformis of the facial nerve. 17. Facial nerve. 18. Chorda tympani nerve, descending to join the gustatory nerve. 19. Gustatory nerve. 20. Submaxillary ganglion, receiving filaments from the chorda tympani and gustatory. 21. Superior cervical ganglion of the sympathetic. * Naso-palatine ganglion of Cloquet.

sometimes joins the ophthalmic ganglion, one the sixth nerve, and two the optic nerve.

The **descending** branches are the three palatine nerves—anterior, middle, and posterior.

The **anterior** or **large palatine nerve** descends from the ganglion through the posterior palatine canal, and emerges at the posterior palatine foramen. It then passes forward in the substance of the hard palate to which it is distributed, and communicates with the naso-palatine nerve. While in the posterior palatine

canal, this nerve gives off several branches (*inferior nasal*), which enter the nose through openings in the palate bone, and are distributed to the middle and inferior meatus, inferior spongy bone, and antrum.

The **middle** or **external palatine nerve** descends externally to the preceding to the posterior palatine foramen, and distributes branches to the tonsil, soft palate, and uvula.

The **posterior** or **small palatine nerve** quits the other nerves to enter a distinct canal, from which it emerges by a separate opening behind the posterior palatine foramen. It is distributed to the hard palate and gums near the point of its emergence, and also to the tonsil, soft palate, and uvula.

The **internal branches** are the superior nasal and naso-palatine. The **superior nasal nerves**, four or five in number, enter the nasal fossa through the spheno-palatine foramen, and are distributed to the mucous membrane of the superior meatus, and superior and middle spongy bone.

The **naso-palatine nerve** (Scarpa) enters the nasal fossa through the spheno-palatine foramen, and crosses the roof of the nares to reach the septum, to which it gives filaments. It then curves downwards and forwards along the vomer, to the naso-palatine canal, and passes through that canal to the palate, to which and to the papilla behind the incisor teeth it is distributed. This nerve was described by Cloquet as uniting with its fellow in the naso-palatine canal and constituting the *naso-palatine ganglion.* The existence of this ganglion is disputed. The naso-palatine nerves are directly continuous with the spheno-palatine, derived from the superior maxillary, and are unconnected with the nerve cells of the ganglion.

The **posterior branches** are the Vidian or pterygoid nerve, and the pterygo-palatine.

The **Vidian nerve**, derived from the back part of the ganglion, passes directly backwards through the pterygoid or Vidian canal to the foramen lacerum basis cranii, where it divides into two branches, *carotid* and *petrosal.* The **carotid branch** (n. petrosus profundus) crosses the foramen lacerum, surrounded by the cartilaginous substance which closes that opening, and enters the carotid canal to join the carotid plexus. The **petrosal branch** (n. petrosus superficialis major) enters the cranium through the foramen lacerum basis cranii, piercing the cartilaginous substance, and passes backwards beneath the Gasserian ganglion and dura mater, embedded in a groove on the anterior surface of the petrous bone to the hiatus Fallopii. In the hiatus Fallopii it receives a branch from Jacobson's nerve, and terminates in the intumescentia gangliformis of the facial nerve. The Vidian nerve is that by which Meckel's ganglion derives its motor power.

The **pterygo-palatine** nerve is a small branch which passes backwards through the pterygo-palatine canal with the pterygo-palatine artery, to be distributed to the mucous membrane of the Eustachian tube and neighbouring part of the pharynx.

Roots.—The spheno-palatine ganglion gets its *motor root* from the facial through the Vidian nerve, its *sensory roots* are the spheno-palatine branches of the superior maxillary, and its *sympathetic root* is derived from the carotid plexus through the Vidian nerve.

The **OTIC GANGLION** (Arnold's) is a small oval-shaped and flattened ganglion, lying against the inner surface of the inferior maxillary nerve, close to the foramen ovale; it is in *relation, externally*, with the trunk of that nerve, just at the point of union of the motor root; *internally* it rests against the cartilage of the Eustachian tube and tensor palati muscle; and *posteriorly* is in contact with the arteria meningea media. It is closely adherent to the internal pterygoid nerve, and appears like a swelling on that nerve.

The branches of the otic ganglion are six in number; two of distribution and four of communication.

The **branches of distribution** are—a small filament to the tensor tympani muscle, and one or two to the tensor palati.

The **branches of communication** are—one or two filaments from

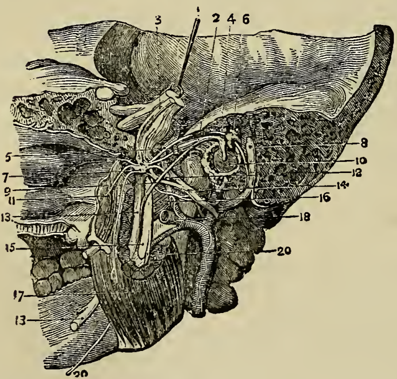


FIG. 319.—Dissection showing inferior maxillary nerve and otic ganglion. 1. Sensory portion of fifth nerve, with Gasserian ganglion. 2. Tensor tympani. 3. Motor portion of fifth, passing beneath ganglion. 4. Malleus. 5. Small superficial petrosal nerve. 6. Incus. 7. Otic ganglion. 8. Facial nerve. 9. Chorda tympani. 10. Membrana tympani. 11. Tensor palati. 12. Middle meningeal artery. 13, 13. Gustatory nerve. 14. Auriculo-temporal nerve. 15. Inferior dental nerve. 16. External pterygoid. 17. Internal pterygoid. 18. Internal maxillary artery. 20, 20. Mylo-hyoid nerve.

the inferior maxillary nerve; one or two filaments from the auriculo-temporal nerve; filaments from the nervi molles of the arteria meningea media, and the *nervus petrosus superficialis minor.* The latter nerve ascends from the ganglion to a small canal situated between the foramen ovale and foramen spinosum, and passes backwards on the petrous bone to the hiatus Fallopii, where it divides into two filaments. One of these filaments enters the hiatus and joins the intumescentia gangliformis of the facial; the other passes to a minute foramen nearer the base of the petrous bone, and enters the tympanum, where it communicates with a branch of Jacobson's nerve.

Roots.—The *motor roots* of this ganglion are the lesser petrosal

nerve, a branch of the facial, and filaments derived from the nerve to the internal pterygoid muscle; the *sensory root* comes from the auriculo-temporal, and the *sympathetic root* from the nervi molles on the middle meningeal artery.

The **SUBMAXILLARY GANGLION** (Wharton's) is a small round or triangular ganglion situated on the deep portion of the submaxillary gland, in close relation with the gustatory nerve, and near the posterior border of the mylo-hyoid muscle.

Its **branches of distribution**, six or eight in number, divide into many filaments, which supply the side of the tongue, the submaxillary gland, sublingual gland, and Wharton's duct.

Its **branches of communication** are two or three from and to the gustatory nerve; one from the chorda tympani; two or three which form a plexus with branches of the hypoglossal nerve; and one or two filaments which pass to the facial artery, and communicate with the nervi molles from the cervical portion of the sympathetic.

Roots.—The *motor root* of the submaxillary ganglion is derived from the hypoglossal; the *sensory* root from the gustatory branch of the inferior maxillary, and the *sympathetic root* from the filaments which accompany the facial artery (nervi molles).

CAROTID PLEXUS.—The ascending branch of the superior cervical ganglion enters the carotid canal with the internal carotid artery, and divides into two branches, which form several loops of communication with each other around the artery. These branches, together with those derived from the carotid branch of the Vidian, constitute the **carotid plexus.** They also form frequently a small gangliform swelling at the under part of the artery, which is called the **carotid ganglion.** The latter, however, is not constant. The continuation of the carotid plexus onwards with the artery by the side of the sella turcica, is the **cavernous plexus.**

The **carotid plexus** is the centre of communication between all the cranial ganglia, and, being derived from the superior cervical ganglion, between the cranial ganglia and those of the trunk; it also communicates with most of the cerebral nerves, and distributes filaments with each of the branches of the internal carotid, to accompany those branches to their ultimate ramifications. The branches which accompany the anterior cerebral artery at each side, unite upon the anterior communicating artery, and according to Ribes form a small ganglion, the *ganglion of Ribes.* The existence of this ganglion is disputed.

The *ophthalmic ganglion* communicates with the plexus by means of the long branch which reaches it from the cavernous plexus. The *spheno-palatine* joins the plexus by means of the carotid branch of the Vidian. The *otic ganglion* is brought into connection with the plexus by means of the tympanic nerve and Vidian.

It communicates with the third nerve in the cavernous sinus, and through the ophthalmic ganglion; frequently with the fourth in the formation of the nerve of the tentorium; with the Gasserian

ganglion; with the *ophthalmic* division of the fifth in the cavernous sinus, and by means of the ophthalmic ganglion; with the superior maxillary, through the spheno-palatine ganglion; and with the inferior maxillary, through the otic ganglion. It sends two branches directly to the sixth nerve, which unite with it as it crosses the cavernous sinus; it communicates with the facial and auditory nerve, through the medium of the petrosal branch of the Vidian; and with the glosso-pharyngeal by means of two filaments to the tympanic nerve.

CERVICAL PORTION OF THE SYMPATHETIC NERVE.

The **superior cervical ganglion** is long and fusiform, of a reddish-grey colour, smooth, and of considerable thickness, extending from within an inch of the carotid foramen in the petrous bone to opposite the lower border of the third cervical vertebra. It is in relation, in front, with the sheath of the internal carotid artery and internal jugular vein; and, behind, with the rectus anticus major muscle.

Its **branches** are divisible into *superior*, *inferior*, *external*, and *internal;* to which may be added, as proper to this ganglion, *anterior.*

The **superior** (carotid nerve) is a single branch which ascends by the side of the internal carotid, and divides into two branches; one lying to the outer, the other to the inner side of that vessel. The two branches enter the carotid canal, and, by their communications with each other and with the carotid branch of the Vidian, constitute the *carotid plexus.*

The **inferior** or descending branch, sometimes two, is the cord of communication with the middle cervical ganglion.

The **external branches** are numerous, and may be divided into two sets: those which communicate with the glosso-pharyngeal, pneumogastric, and hypoglossal nerve, and those which communicate with the first four cervical nerves.

The **internal branches** are three in number: **pharyngeal**, to assist in forming the pharyngeal plexus; **laryngeal**, to join the superior laryngeal nerve, and its branches; and **superior cardiac nerve**, or nervus superficialis cordis.

The **anterior branches** accompany the external carotid artery with its branches, around which they form plexuses, and here and there small ganglia; they are named, from the softness of their texture, **nervi molles**, and from their reddish hue, *nervi subrufi.* The branches accompanying the facial artery are conducted by that vessel to the submaxillary ganglion, and those which accompany the internal maxillary artery reach the otic ganglion through the medium of the middle meningeal artery.

The **middle cervical ganglion** (thyroid ganglion) is small, and sometimes wanting. It is situated opposite the fifth cervical

vertebra, and rests against the inferior thyroid artery. This relation is so constant, as to have induced Haller to name it the "thyroid ganglion."

Its **superior branch**, or branches, ascend to communicate with the superior cervical ganglion.

Its **inferior branches** descend to join the inferior cervical ganglion; one of these frequently passes in front of the subclavian artery, the other behind it.

Its **external branches** communicate with the fifth and sixth cervical nerve.

Its **internal branches** are filaments which accompany the inferior thyroid artery, **inferior thyroid plexus**; and the **middle cardiac nerve**, nervus cardiacus magnus.

The **inferior cervical ganglion** (vertebral ganglion) is much larger than the preceding, and constant in its existence. It is of a semilunar form, and situated on the base of the transverse process of the seventh cervical vertebra, immediately behind the vertebral artery; hence its designation "*vertebral ganglion.*"

Its **superior branches** communicate with the middle cervical ganglion.

The **inferior branches** pass some before and some behind the subclavian artery, to join the first thoracic ganglion.

The **external branches** consist of two sets; one which communicates with the sixth, seventh, and eighth cervical, and first dorsal nerve, and one which accompanies the vertebral artery along the vertebral canal, forming the **vertebral plexus.** The plexus sends filaments to all the branches given off by that artery, and communicates in the cranium with the filaments of the carotid plexus accompanying the branches of the internal carotid artery.

The **internal branch** is the **inferior cardiac nerve,** nervus cardiacus minor.

CARDIAC NERVES.—The cardiac nerves are three in number at each side—namely, superior, middle, and inferior.

The **superior cardiac nerve** (*nervus superficialis cordis*) proceeds from the lower part of the superior cervical ganglion; it descends the neck behind the common carotid artery and parallel with the trachea, crosses the inferior thyroid artery, and running by the side of the recurrent laryngeal nerve, enters the chest. The nerve of the right side passes either in front of or behind the subclavian artery and along the posterior aspect of the arteria innominata to the deep cardiac plexus. The left superior cardiac nerve runs by the side of the left carotid artery, and crosses the arch of the aorta to the superficial cardiac plexus.

In its course it receives branches from the pneumogastric nerve, and sends filaments to the thyroid gland and trachea.

The **middle cardiac nerve** (*nervus cardiacus magnus*) proceeds from the middle cervical ganglion, or in its absence, from the cord of communication between the superior and inferior ganglion. It is the largest of the three nerves, and lies parallel with the recurrent

laryngeal. At the root of the neck it divides into several branches, which pass some before and some behind the subclavian artery, communicates with the superior and inferior cardiac, pneumogastric, and recurrent nerve, and descends to the bifurcation of the trachea, to join the *deep cardiac plexus.* On the left side this nerve passes between the left carotid and subclavian arteries to reach the chest, and terminates in the left side of the deep cardiac plexus.

The **inferior cardiac nerve** (*nervus cardiacus minor*) arises from the inferior cervical ganglion, communicates with the recurrent laryngeal and middle cardiac nerve, and descends to the front of the bifurcation of the trachea, to the *deep cardiac plexus.* The nerve of the left side often unites with the middle cardiac nerve, either before or immediately after they enter the thorax, the combined cord joining the deep cardiac plexus.

The **SUPERFICIAL CARDIAC PLEXUS** is situated immediately beneath the arch of the aorta and in front of the right pulmonary artery. It receives the superior cardiac nerve of the *left* side and the inferior cardiac branch of the *left* pneumogastric nerve, both of which cross the arch of the aorta between the left phrenic and pneumogastric nerve. It receives besides several filaments from the deep cardiac plexus, and sometimes a cardiac branch from the right pneumogastric nerve. Connected with the plexus is a small ganglion (sometimes wanting), the **cardiac ganglion of Wrisberg,** which lies close to the right side of the fibrous cord of the ductus arteriosus. The superficial cardiac plexus gives off filaments which pass along the front of the left pulmonary artery to the root of the left lung, where they communicate with the anterior pulmonary plexus; while the principal part of the plexus descends in the groove between the pulmonary artery and aorta to the anterior longitudinal *sulcus* of the heart, where it comes into relation with the anterior coronary artery, and becomes the **anterior coronary plexus.** At the base of the heart, the anterior coronary plexus receives several filaments from the deep cardiac plexus. Its branches are distributed to the substance of the heart in the course of the left or anterior coronary artery.

The **DEEP** or **GREAT CARDIAC PLEXUS** is situated on the bifurcation of the trachea, above the right pulmonary artery and behind the transverse portion of the arch of the aorta. It receives on the *right* side, the three cardiac nerves of the sympathetic of the same side, and the cardiac branches of the right pneumogastric and right recurrent nerve. On the *left* side it receives the middle and inferior cardiac nerves of the sympathetic of the left side; the cardiac branches of the left pneumogastric (excepting the inferior), and several cardiac branches from the left recurrent nerve. In other words, it receives all the cardiac filaments of the sympathetic, pneumogastric, and recurrent nerves, with the exception of the left superior cardiac of the sympathetic (nervus superficialis cordis) and the inferior cervical cardiac of the left pneumogastric, these two nerves being destined to the superficial cardiac plexus.

The **branches** of the deep cardiac plexus, proceeding from its right and left division, pass downwards to join the coronary arteries, and outwards to the pulmonary plexuses.

From the **right division** of the plexus the branches proceed before and behind the right pulmonary artery. Those which pass in front descend upon the trunk of the pulmonary artery to the left coronary artery, and help to form the *anterior coronary plexus;* those which pass behind the right pulmonary artery are distributed to the right auricle ; a third set of filaments, proceeding from the right division of the deep cardiac plexus, follow the course of the right pulmonary artery to the anterior pulmonary plexus.

From the **left division** of the plexus branches proceed beneath the arch of the aorta immediately to the right of the ligament of the ductus arteriosus to join the superficial cardiac plexus ; others pass outwards with the pulmonary artery to the pulmonary plexus ; a few descend to the left auricle ; but the chief bulk pass on to the right coronary artery and form the *posterior coronary plexus.*

The **anterior coronary plexus** proceeds from the superficial cardiac plexus, and receives other filaments from the deep cardiac plexus. It is distributed with the branches of the coronary artery on the anterior aspect of the heart.

The **posterior coronary plexus** proceeds from the deep cardiac plexus, and principally from its left division. It follows the course of the arteries distributed to the posterior aspect of the heart.

THORACIC PORTION OF THE SYMPATHETIC NERVE.

The thoracic portion of the sympathetic nerve is the trunk of the sympathetic in its course through the cavity of the thorax. It lies by the side of the vertebral column on the heads of the ribs and intercostal spaces, but at its lowest part comes into relation with the sides of the bodies of the two last dorsal vertebræ.

The **THORACIC GANGLIA** (fig. 299, 31) are twelve in number at each side. They are flattened and triangular, or irregular in form, and present the peculiar reddish-grey colour and pearly lustre of sympathetic ganglia in general ; they rest against the heads of the ribs, and are covered by the pleura costalis. The first two ganglia and the last are usually the largest ; the latter being situated on the side of the body of the last dorsal vertebra.

Their **branches** are branches of communication and branches of distribution. Some ascending filaments from the first ganglion assist in the formation of the vertebral plexus.

The **external** or **communicating branches**, usually two in number for each ganglion, communicate with the intercostal nerves ; of these, one is greyish in colour, and is believed to pass from the ganglion to the spinal nerve ; the other, of a white colour, probably is spinal in its origin, and is distributed with the sympathetic nerves.

The **internal** or **visceral branches** proceeding from the five or

six upper ganglia, are of small size, and distributed to the aorta, œsophagus, vertebral column, and lungs. The branches to the lungs proceed from the third and fourth ganglia, and go to join the posterior pulmonary plexus. The visceral branches of the six lower ganglia unite to form the three splanchnic nerves.

The **great splanchnic nerve** proceeds from the sixth dorsal ganglion, and receiving the branches of the seventh, eighth, ninth, and tenth, passes downwards along the front of the vertebral column, and, piercing the crus of the diaphragm, terminates in the semilunar ganglion.

The **lesser splanchnic nerve** is formed by filaments which issue from the tenth and eleventh ganglia; it pierces the crus of the diaphragm, and joins the solar plexus near the middle line, frequently distributing branches also to the renal plexus.

The **third** or **renal splanchnic nerve** proceeds from the last thoracic ganglion, and, piercing the diaphragm, terminates in the renal plexus. When absent, the place of this nerve is supplied by the lesser splanchnic.

The **semilunar ganglion** is a large, irregular, gangliform body, pierced by numerous openings, and appearing like the aggregation of a number of smaller ganglia, having spaces between them. By its upper and posterior extremity each ganglion receives the corresponding great splanchnic nerve. It is situated by the side of the cœliac axis and root of the superior mesenteric artery, and extends outwards to the supra-renal capsule. The ganglia communicate both above and below the cœliac axis and form a gangliform circle, from which branches pass off in all directions, like rays from a centre. Hence the entire circle has been named the *solar plexus.*

The **solar** or **epigastric plexus** receives the great and lesser splanchnic nerves, the termination of the right pneumogastric nerve, some filaments from the right phrenic nerve, and sometimes one or two from the left. It sends forth numerous filaments which accompany, under the name of **plexuses**, all the branches given off by the abdominal aorta. Thus we have derived from the solar plexus the—

- Phrenic, or diaphragmatic plexuses,
- Gastric plexus,
- Hepatic plexus,
- Splenic plexus,
- Supra-renal plexuses,
- Renal plexuses,
- Superior mesenteric plexus,
- Aortic plexus,
- Spermatic plexuses,
- Inferior mesenteric plexus.

In connection with the **phrenic plexus** of the right side, there is described a small **ganglion diaphragmaticum**, which is situated near the supra-renal capsule. In this ganglion branches of the right phrenic nerve communicate with those of the sympathetic.

The **supra-renal plexuses** are remarkable for their large size, and for a ganglion, which has received the name of ganglion suprarenale.

The **renal plexuses** are large, and receive the third splanchnic nerve.

The **superior mesenteric plexus** has several small ganglia at the root of the artery; and its nerves, which are whiter than those of the other plexuses, form a kind of nervous sheath to the artery and its branches.

The **aortic plexus** is a continuation of the solar plexus downwards on the aorta, for the supply of the inferior branches of that trunk; it receives also branches from the renal plexuses and lumbar ganglia. It is the source of origin of the inferior mesenteric plexus and part of the spermatic plexus, and terminates below in the hypogastric plexus. It likewise distributes branches on the inferior vena cava.

The **spermatic plexus** is derived from the renal plexus, but receives filaments from the aortic plexus.

The **inferior mesenteric plexus** is derived chiefly from the aortic plexus.

LUMBAR PORTION OF THE SYMPATHETIC NERVE.

The lumbar portion of the trunk of the sympathetic is situated on the vertebral column, close to the anterior border of the psoas magnus muscle. It is continuous above, under the edge of the diaphragm, with the thoracic portion of the nerve, and below it descends upon the sacrum, in front of the anterior sacral foramina, to the coccyx. It presents four small ganglia and an intermediate cord.

The **lumbar ganglia**, four in number at each side, of a pearly grey colour and fusiform shape, are situated on the anterior part of the bodies of the lumbar vertebræ.

The **branches** of the lumbar ganglia are branches of communication and branches of distribution.

The **external** or **communicating branches**, two or three in number from each ganglion, and longer than in the other regions, communicate with the lumbar nerves.

The **internal** or **visceral branches** consist of two sets: the upper pass inwards in front of the abdominal aorta, and join the **aortic plexus**; the lower cross the common iliac arteries, and unite over the promontory of the sacrum to form the hypogastric plexus.

The **hypogastric plexus** is formed by the termination of the aortic plexus, and by the union of branches from the lower lumbar ganglia. It is situated over the promontory of the sacrum, between the two common iliac arteries, and bifurcates inferiorly into two lateral portions, **inferior hypogastric plexuses**, which communicate with branches from the third and fourth sacral nerves. It distributes branches to the viscera of the pelvis, and sends filaments which accompany the branches of the internal iliac artery.

SACRAL PORTION OF THE SYMPATHETIC NERVE.

The **sacral ganglia** are four or five in number at each side. They are situated on the sacrum, close to the anterior sacral foramina, and resemble the lumbar ganglia in form and mode of connection, although much smaller in size.

The **external** or **communicating branches** are two from each ganglion, which pass outwards to communicate with the anterior sacral nerves and with the coccygeal nerve.

The **internal** or **visceral branches** communicate very freely with the inferior hypogastric plexuses, and are distributed to the pelvic viscera. The last pair of sacral ganglia give off branches which join a small ganglion, situated on the first bone of the coccyx, called the *ganglion impar*, or *azygos*. This ganglion serves to connect the extremities of the two sympathetic nerves. It gives off a few small branches to the coccyx and rectum, and communicates with the coccygeal nerve.

COCCYGEAL GLAND.

Numerous branches from the ganglion impar are given off to a peculiar reddish body situated on the anterior aspect of the tip of the coccyx, and called by Luschka, by whom it was first described, the *coccygeal gland*. It consists of an aggregation of little lobules or granules, and has been shown by Arnold to be formed by a number of dilated and tortuous arteries connected with the middle sacral artery. In the stroma of the organ scattered nerve cells are found.

ORGANS OF SENSE.

The organs of sense, the instruments by which the animal frame is brought into relation with surrounding nature, are five in number. Four of these organs are situated within the head; viz., the apparatus of smell, sight, hearing, and taste; the remaining organ, that of touch, is resident in the skin, and distributed over the surface of the body.

THE NOSE AND NASAL FOSSÆ.

The organ of smell consists essentially of two parts: one external, the **nose**; the other internal, the **nasal fossæ**.

The nose is the triangular pyramid which projects from the centre of the face, immediately above the upper lip. Superiorly it is connected with the forehead by means of a narrow bridge; inferiorly, it presents two openings, the **nostrils**, which overhang the mouth, and are so constructed that the odour of all substances must be received by the nose before they can be introduced within the lips. The septum between the openings of the nostrils is called the

columna. Their entrance is guarded by a number of stiff hairs (*vibrissæ*) which project across the openings, and act as a filter in preventing the introduction of foreign substances, such as dust or insects, with the current of air intended for respiration.

The anatomical elements of which the nose is composed are: 1. Integument. 2. Muscles. 3. Bones. 4. Fibro-cartilages. 5. Mucous membrane. 6. Vessels and nerves.

1. The **integument** forming the tip (*lobulus*) and wings (*alæ*) of the nose is extremely thick and dense, so as to be with difficulty separated from the fibro-cartilage. It is furnished with an abundance of *sebaceous glands*, which, by their oily secretion, protect the extremity of the nose under alternations of temperature. The sebaceous matter of these glands becomes of a dark colour near the surface, from altered secretion, and also from attraction of the carbonaceous matter floating in the atmosphere; hence the spotted appearance which the tip of the nose presents in large cities. When the integument is firmly compressed, the inspissated sebaceous secretion is squeezed out, and taking the cylindrical form of the excretory ducts of the glands, has the appearance of small white maggots (grubs; comedones) with black heads.

2. The **muscles** are brought into view by reflecting the integument; they are the pyramidalis nasi, compressor nasi, dilatator naris, levator labii superioris alæque nasi, and depressor alæ nasi. They have been already described with the muscles of the face.

3. The **bones** of the nose are—the nasal, and nasal processes of the superior maxillary.

4. The **fibro-cartilages** give form and stability to the nose, providing, at the same time, by their elasticity, against injuries. They are five in number, namely, the—

Fibro-cartilage of the septum,
Two lateral fibro-cartilages,
Two alar fibro-cartilages.

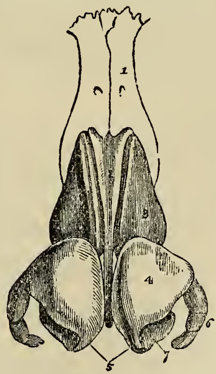


FIG. 320. — The fibro-cartilages of the nose. 1. One of the nasal bones. 2. Cartilage of the septum. 3. Lateral cartilage. 4. Alar cartilage. 5. Central portions of the alar cartilages which constitute the columna. 6. Sesamoid cartilages. 7. The nostril.

The **fibro-cartilage of the septum**, somewhat triangular in form, divides the nose into its two nostrils. It is connected above with the nasal bones and lateral fibro-cartilages; behind, with the ethmoidal septum and vomer; and below, with the palate processes of the superior maxillary bones. The alar fibro-cartilages and columna move freely on the fibro-cartilage of the septum, being but loosely connected with it by perichondrium.

The **lateral fibro-cartilages** are also triangular; they are connected, *in front*, with the fibro-cartilage of the septum; *above*, with

the nasal bones; *behind*, with the nasal processes of the superior maxillary bones; and *below*, with the alar fibro-cartilages.

Alar Fibro-cartilages (lower lateral cartilages).—Each of these cartilages is curved so as to correspond with the walls of the nostril, to which it forms a kind of rim. The inner portion is loosely connected with the same part of the opposite cartilage, to form the *columna*. It is expanded and thickened at the point of the nose, to constitute the *lobe*; and on the side makes a curve corresponding with that of the ala. This curve is prolonged backwards and downwards in the direction of the posterior border of the ala by three or four small fibro-cartilaginous plates (**sesamoid cartilages**), which are appendages of the alar fibro-cartilage.

The whole of the fibro-cartilages are connected with each other, and to the bones, by perichondrium, which, from its membranous structure, permits of the freedom of motion existing between them.

FIG. 321.—The fibro-cartilages and bones of the nose viewed from the side. 1. Nasal bone. 2. Nasal process of the superior maxillary bone. 3. Cartilage of the septum. 4. Lateral cartilage. 5, 5. Alar cartilage. 6. Inner portion of the alar cartilage. 7. Sesamoid cartilages. 8. Areolar tissue of the ala nasi. 9. Aperture of the nostril.

The lower margin and back part of the ala of the nose is devoid of cartilage, and is composed of areolar and elastic tissue to which the skin is closely adherent; it resembles the lobule of the ear.

5. The **mucous membrane**, lining the interior of the nose, is continuous with the skin externally, and with the pituitary membrane of the nasal fossæ within. Around the entrance of the nostrils it is provided with the *vibrissæ*.

6. **Vessels and Nerves.**—The *arteries* of the nose are—the lateral nasal from the facial, and the artery of the septum from the superior coronary.

Its *nerves* are—the facial, infra-orbital, and nasal branch of the ophthalmic.

NASAL FOSSÆ.

To obtain a good view of the *nasal fossæ*, the face must be divided through the nose by a vertical incision, a little to one side of the middle line.

The **nasal fossæ** are two irregular, compressed cavities, extending backwards from the nose to the pharynx. They are bounded *superiorly* by the lateral cartilages of the nose, and by the nasal bones, ethmoid, and sphenoid; *inferiorly* by the hard palate; and, in the *middle* line, they are separated by a bony and fibro-cartilaginous

septum. A plan of the boundaries of the nasal fossæ will be found at p. 113.

On the outer wall of each fossa, in the dried skull, are three projecting processes, termed spongy bones. The two superior belong to the ethmoid, the inferior is a separate bone. In the fresh fossæ these are covered with mucous membrane, and serve to increase the surface of that membrane by their prominence and convoluted form. The space intervening between the superior and middle spongy bone is the **superior meatus**; the space between the middle and inferior the **middle meatus**; and that between the inferior and the floor of the fossa the **inferior meatus**.

These *meatuses* are passages which extend from before backwards, and it is in circulating through and amongst them that the atmosphere deposits its odorant particles upon the mucous membrane. There are several **openings** into the nasal fossæ; thus, in the **superior meatus** are the openings of the sphenoidal and posterior ethmoidal cells; in the **middle**, the anterior ethmoidal cells, frontal sinuses, and antrum maxillare; and, in the **inferior** meatus, the termination of the nasal duct and of the Eustachian tube. In the dried bone there are two additional openings, the spheno-palatine and the anterior palatine foramen; the former being situated in the superior, the latter in the inferior meatus.

The **mucous membrane** of the nasal fossæ is called *pituitary*, or *Schneiderian.* The former name being derived from the nature of its secretion, the latter from Schneider, who was the first to show that the secretion of the nose proceeded from the mucous membrane, and not from the brain, as was previously imagined. It is closely adherent to the periosteum, constituting what is called a fibro-mucous membrane, and is continuous with the general gastro-pulmonary mucous membrane. From the nasal fossæ it may be traced through the openings in the meatuses, into the sphenoidal and ethmoidal cells; into the frontal sinuses; into the antrum maxillare; through the nasal duct to the surface of the eye, where it is continuous with the conjunctiva; along the Eustachian tubes into the tympanum and mastoid cells, to which it forms the lining membrane; and through the posterior nares into the pharynx and mouth, and thence through the lungs and alimentary canal. Bigelow has pointed out that the mucous membrane covering the middle and inferior turbinated bones contains a true cavernous structure, similar to that of the corpus cavernosum penis. The cavernous spaces are irregular in

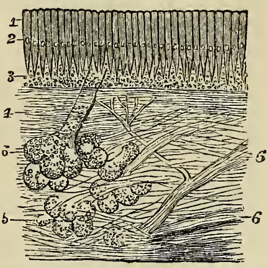


FIG. 322.—A section of the mucous membrane in the olfactory region. 1. Coloured part of the epithelium. 2. Nucleus. 3. Deeper part, containing olfactory cells and filaments. 4. Connective tissue. 5, 5. Mucous glands. 6, 6. Nerve twigs giving off terminal branches.

shape and variable in size; they approach quite near to the surface of the mucous membrane and the bone, and they communicate freely with each other.

The surface of the membrane is furnished with laminated squamous epithelium near the aperture of the nares, and with ciliated columnar epithelium in the respiratory tract; in the latter it is also furnished with mucous glands, which are especially numerous on the septum at its posterior part. The mucous membrane which covers the upper and middle turbinated bones and the upper part of the septum (the olfactory tract) is of a darker colour, softer and more pulpy, its epithelium is columnar and non-ciliated, and the epithelial processes are prolonged at their deep extremities into threads which appear to join the connective tissue corpuscles. It also contains numerous glands, but these are more simple than the glands of the respiratory tract. Mingled with the cells of the columnar epithelium are certain peculiar rod-like bodies, each of which is connected with or grows out from a nucleated cell (*olfactory cell*), while from the deeper surface of the same cell proceeds a fine thread, which is supposed to be continuous with a filament of the olfactory nerve, although this has never been satisfactorily proved. They bear a striking resemblance to the retinal rods and cones.

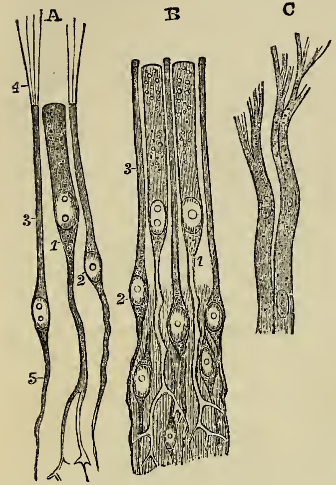


FIG. 323.—Olfactory cells and nerve terminations. A. Olfactory cells from frog. B. From man. C. Filaments of olfactory nerve from dog. 1. Epithelial cells, extending deeply into ramified processes. 2. Olfactory cells. 3. The rod-like processes of olfactory cells. 4. Their ciliated extremities. 5. Their central filaments.

Vessels and Nerves.—The *arteries* of the nasal fossæ are the anterior and posterior ethmoidal, from the ophthalmic; and spheno-palatine and pterygo-palatine from the internal maxillary.

The *nerves* are—olfactory, spheno-palatine and naso-palatine from Meckel's ganglion, and nasal branch of the ophthalmic.

The filaments of the olfactory nerves differ from those of the cerebral and spinal nerves generally, in being devoid of the medullary sheath; they form a fine anastomotic network, and probably terminate in the olfactory cells above described. In the frog the olfactory fibres have been observed breaking up into a whole bundle of fine, pale, varicose fibrils which perforate the mucous membrane, and each of these appears then to join an olfactory cell (Schultze and Kölliker).

ORGAN OF VISION.

The organ of vision consists of the two eyes and their connections with the brain.

The eyes are situated in the orbital fossæ, on each side of the upper part of the face ; they are freely movable in consequence of being surrounded by fat and contained in a smooth fibrous capsule (*capsule of Tenon*), and have numerous muscles to perform their movements. They are protected from external violence by being situated in cavities with osseous walls, and have in front both cleansing and protective apparatus against the intrusion of foreign bodies. The fossæ in which the eyes are situated have their axes directed outwards, but the eyes themselves are directed much more forwards, varying, however, in their direction with the distance or nearness of the object looked at, their axes being parallel in looking at distant objects, but converging slightly when near objects are viewed. The optic nerves follow the direction of the orbits, and therefore enter the eyeballs on their nasal side.

We shall in the first place give a short account of those structures which, although not essential to vision, are provided for the protection of the anterior part of the eye.

These appendages of the eye (*tutamina oculi*) are—the eyebrows, eyelids, eyelashes, conjunctiva, caruncula lachrymalis, and lachrymal apparatus.

APPENDAGES OF THE EYE.

The **eyebrows** (*supercilia*) are two prominent arches of integument which overlie the superciliary ridges of the frontal bone. They are covered with short, stiff hairs directed obliquely upwards and outwards, and are connected beneath with the orbicularis palpebrarum, occipito-frontalis, and corrugator supercilii muscles, by which they are moved. They serve to shade the eyes from too vivid light, to protect them from the entrance of dust from above, and to carry the moisture from the forehead on to the temple and lateral parts of the face, and so prevent its entering the eyes.

The **eyelids** (*palpebræ*) are two movable folds, which serve by their closure to protect the anterior part of the eye from injury, or to exclude the light, as during sleep. When open they have an elliptical fissure between them (*rima palpebrarum*), and it is upon the size of this that the apparent size of the eye depends. The angles of junction of the two lids are called **canthi.** The **outer canthus** is acute, so that but a small space is left between the lids ; the **inner canthus** is prolonged for a short distance towards the nose, and a triangular space called **lacus lachrymalis** is left between the lids in this situation. At the commencement of this space, upon the edge of each of the lids, is a small angular projection, the **lachrymal papilla** ; and at the apex of each papilla is a small

orifice, **punctum lachrymale**, the commencement of the lachrymal canaliculus.

The eyelids have entering into their structure, *integument*, *orbicularis palpebrarum muscle*, *tarsal cartilages*, *palpebral ligament*, *Meibomian glands*, and *conjunctiva.*

The **areolar tissue** of the skin of the eyelids is remarkable for its looseness, and the absence of adipose substance; it is particularly liable to serous infiltration.

The **fibres of the orbicularis** are for the most part thin and pale, but a thicker band of fibres has been found internal to the eyelashes, constituting the *ciliary muscle* of Riolan.

The **tarsal cartilages** are two thin plates of dense connective tissue, about an inch in length, which give form and support to the eyelids.* The *upper* cartilage is of a semilunar form, thicker in the middle than at its extremities; its lower border is broad and flat, its upper thin, and gives attachment to the levator palpebræ muscle and the palpebral ligament. The *lower* cartilage, narrower than the upper, is situated in the substance of the lower lid. Its upper

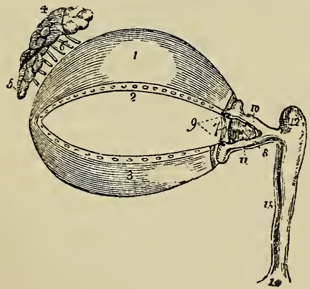


Fig. 324.—Appendages of the eye. 1. Superior tarsal cartilage. 2. Lower border of the cartilage on which are seen the openings of the Meibomian glands. 3. Inferior tarsal cartilage; along the upper border of this cartilage the openings of the Meibomian glands are likewise seen. 4. Lachrymal gland, its superior or orbital portion. 5. Inferior or palpebral portion. 6. Lachrymal ducts. 7. Plica semilunaris. 8. Caruncula lachrymalis. 9. Puncta lachrymalia. 10. Superior lachrymal canaliculus. 11. Inferior lachrymal canaliculus. 12. Lachrymal sac. 14. Dilatation of the nasal duct, where it opens into the inferior meatus of the nose. 15. Nasal duct.

border is flat, and corresponds with the flat edge of the upper cartilage; the lower border is attached to the palpebral ligament.

Near the inner canthus, the tarsal cartilages terminate at the commencement of the lacus lachrymalis, and are attached to the margin of the orbit by the tendo oculi. At their outer extremity they terminate at a short distance from the canthus, and are retained in position by a fibrous band which is part of the palpebral ligament, and is called the *external tarsal ligament.*

The **palpebral ligament** (*broad tarsal ligament*) is a fibrous membrane which is firmly attached to the periosteum around the margin of the orbit, and to the internal free edges of the tarsal cartilages. It is thick and dense for the outer half of the orbit, but becomes thin to its inner side. Its use is to retain the tarsal cartilages in their place, and give support to the lids.

* Microscopic examination fails to detect the presence in them of any cartilage cells; it is nevertheless convenient to retain the title of *cartilage* so long used in their description.

The **Meibomian glands** are embedded in grooves on the under surface of each tarsal cartilage, and are distinctly seen on examining the inner aspect of the lids. They have the appearance of parallel strings of pearls, about thirty in number in the upper cartilage, and somewhat fewer in the lower; they open by minute foramina on the edges of the lids. They correspond in length with the breadth of the cartilage, and are consequently longer in the upper than in the lower lid. Each gland consists of a single lengthened follicle or tube, into which a number of small clusters of glandular vesicles open; the latter are so numerous as almost to conceal the tube by which the secretion is poured out on the edges of the lids. Occasionally an arch is formed between two of the follicles, producing a graceful appearance. The tubes are lined by a stratified epithelium, and the gland vesicles by cubical cells; the lumen of the gland is usually filled up with the fatty secretion and partly disintegrated epithelial cells.

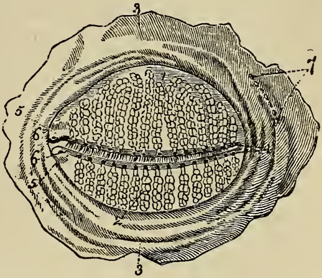


FIG. 325.—Meibomian glands, as seen upon the inner side of the eyelids. 1. Upper lid. 2. Lower lid. 3, 3. Conjunctiva. 4. Apertures of the Meibomian glands, forming a row along the free border of each eyelid. 5, 5. Papillæ lachrymales. 6, 6. Puncta lachrymalia. 7. Apertures of the efferent ducts of the lachrymal gland.

The edges of the eyelids are furnished with strong, short, curved hairs, called **eyelashes** (*cilia*), arranged in two or more rows; those of the upper lid curving upwards, and those of the lower downwards, so as not to interlace with each other in the closure of the lids, and prove an impediment to the opening of the eyes. Their follicles are supplied with sebaceous glands like those of other hairs.

The **conjunctiva** is the mucous membrane of the eye. It covers the whole of its anterior surface, and is reflected on the lids so as to form their internal layer. It is continuous with the general gastro-pulmonary mucous membrane, and sympathises in its affections, as may be observed in various diseases. From the surface of the eye it may be traced through the lachrymal ducts into the lachrymal gland, along the edges of the lids it is continuous with the mucous lining of the Meibomian glands, and at the inner angle of the eye it may be followed through the lachrymal canaliculi into the lachrymal sac, and thence downwards through the nasal duct into the inferior meatus of the nose. Where it covers the cornea the conjunctiva is thin, transparent, and inseparable from the corneal substance; it appears to consist of epithelial cells alone. In the conjunctiva at the circumference of the cornea a plexus of vessels is found, but this never extends entirely across the latter. The conjunctiva over the sclerotic is also thin and transparent, but is

loosely applied and glides freely over the surface of the eyeball; it is freely supplied with blood by an irregularly disposed plexus of vessels. These vessels are readily distinguished from those of the sub-conjunctival tissue, by the latter radiating in nearly straight lines from the circumference of the cornea, and by their not gliding over the surface of the sclerotic on pressure. The sclerotic conjunctiva consists of stratified epithelium with an elastic basement membrane.

The palpebral conjunctiva is thick, opaque, and red; it presents numerous papillæ on its surface, and very closely resembles ordinary mucous membrane in structure. It consists of several layers of nucleated epithelium, a basement membrane, and elastic submucous tissue; in the latter, numerous simple follicles are found, and near the reflected portion, certain racemose glands, similar in structure to the lachrymal gland.

Between the eyelids and ball of the eye the conjunctiva forms an upper and lower fold, which are called the **superior** and **inferior palpebral folds** (*retro-tarsal folds*); it is in these that minute foreign bodies frequently become lodged.

The **caruncula lachrymalis** is the small reddish body which occupies the lacus lachrymalis at the inner canthus of the eye. In health it presents a bright pink tint; in sickness it loses its colour and becomes pale. It is studded with fine hairs, and consists of a dozen racemose sebaceous glands, with some few fat cells intermingled.

Immediately to the outer side of the caruncula is a slight duplicature of the cunjunctiva, called **plica semilunaris**; it is simply a fold of conjunctiva, and is the rudiment of the third lid or *membrana nictitans* of birds.

Vessels and Nerves.—The eyelids and other appendages of the eye are supplied with blood by the nasal, palpebral, and lachrymal branches of the ophthalmic, and the angular branch of the facial artery. The nerves are derived from the facial and fifth nerves.

LACHRYMAL APPARATUS.

The lachrymal apparatus consists of the lachrymal gland with its excretory ducts; the puncta lachrymalia and lachrymal canaliculi; the lachrymal sac and nasal duct.

The **lachrymal gland** is situated at the upper end and outer part of the orbit, in a depression of the orbital plate of the frontal bone, with the periosteum of which bone it is connected by fibrous bands; by its under surface it is in relation with the globe of the eye, and the superior and external rectus muscles. It is oval in shape, about three-quarters of an inch long, convex on its upper and concave on its under surface. The anterior portion is frequently separated from the rest by a slight depression, and is then described as the *palpebral portion;* it is situated in the upper eyelid, and extends downwards to the superior margin of the tarsal carti-

lage. The gland consists of a number of aggregated racemose glands similar in structure to the salivary and mucous glands. The secretion is conveyed away by from eight to twelve small ducts which run for a short distance beneath the conjunctiva, and open on its surface by separate orifices, about a twentieth of an inch apart, the greater number in the fold above the outer canthus, and two of them in the fold below.

The **lachrymal canaliculi** commence at the minute openings, puncta lachrymalia, seen on the lachrymal papillæ of the lids at the outer extremity of the lacus lachrymalis, and proceed inwards to the lachrymal sac, where they terminate beneath a valvular semilunar fold of mucous membrane (*valve of Huschke*). The *superior* duct is the narrower and longer of the two; it at first ascends and then suddenly turns inwards towards the sac, forming an abrupt angle. The *inferior* duct forms the same kind of angle by descending at first and then turning abruptly inwards. Both canals are dilated where they are bent. A valve-like projection (*valve of Foltz*) has been described as projecting from the side into the interior of the vertical portion of each canaliculus near the punctum lachrymale; it seems to be sufficient to close the tube completely when it is flattened by the orbicularis and tensor tarsi muscles. It no doubt prevents the tears being driven back when such pressure is applied, as in winking; and as a consequence they are then driven forward into the lachrymal sac. The two fasciculi of the tensor tarsi muscle are inserted into the canaliculi, and serve to draw them inwards and compress them.

The **lachrymal sac** is the dilated upper extremity of the nasal duct. It is lodged in the groove of the lachrymal bone, and is often distinguished internally from the nasal duct by a semilunar or circular valve. The sac consists of mucous membrane, but is covered in and retained in place by a fibrous expansion, derived from the tendon of the orbicularis, which is inserted into the ridge on the lachrymal bone; it is also covered by the tensor tarsi muscle, which arises from the same ridge, and when in action makes pressure on the lachrymal sac.

The **nasal duct** is a short canal, about three-quarters of an inch in length, directed downwards, backwards, and a little outwards to the inferior meatus of the nose, into which it opens. It is lined by mucous membrane, which is continuous with the conjunctiva above, and with the pituitary membrane of the nose below; it frequently forms an imperfect valve (*valve of Hasner*) at the lower opening of the duct.

The mucous membrane of the canaliculi is covered by a stratified scaly epithelium, and that of the lachrymal sac and nasal duct by columnar ciliated cells.

Vessels and Nerves.—The lachrymal gland is supplied with blood by the lachrymal branch of the ophthalmic artery, with nerves by the lachrymal branch of the ophthalmic, and the orbital branch of the superior maxillary.

GLOBE OF THE EYE.

The globe or ball of the eye is irregularly spheroidal in form, having the segment of a smaller sphere (the cornea) projecting from it anteriorly, and being slightly flattened behind. Its transverse diameter is an inch, its antero-posterior and vertical diameters being a little short of this (.96 in.). Around the eyeball is a layer of fascia which separates it from the fat of the orbit, and enables it to move smoothly; this is the so-called *tunica vaginalis oculi*, or *capsule of Tenon;* it is pierced by the tendons of the straight and oblique muscles, and is connected with the sclerotic by means of delicate fibrous threads.

The globe of the eye is composed of a strong external fibrous coat, called the *sclerotic*, with its clear anterior portion, the *cornea;* a middle vascular and pigmentary covering, the *choroid*, which is

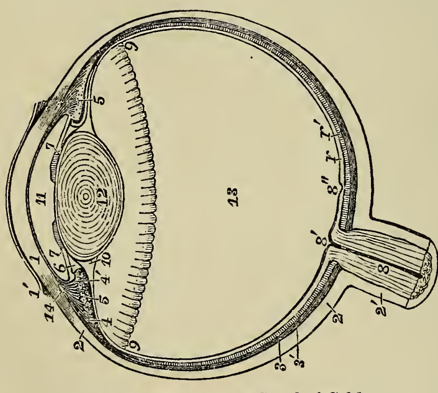


FIG. 326.—General diagram of the eye. 1. Cornea. 1′. Corneal conjunctiva. 2. Sclerotic. 2′. Sheath of the optic nerve, which is seen to be continuous with the sclerotic. 3. Vascular layers of the choroid. 3′. Pigmentary layer. 4. Radiating portion of the ciliary muscle. 4′. Cut fibres of circular portion, or *muscle of Müller*. 5, 5. Ciliary processes. 6. Posterior chamber of the aqueous humour. 7, 7. Iris. 8. Optic nerve. 8′. Optic cumulus. 8″. Yellow spot. 9. Ora serrata. 10. Canal of Petit. 11. Anterior chamber of the aqueous humour. 12. Crystalline lens. 13. Chamber of the vitreous humour. 14. Canal of Schlemm. *r.* Nervous layers of the retina. *r′*. Bacillary and molecular layers of the retina.

also continued forwards to form a partition, the *iris;* and an internal nervous tunic, the *retina*. It encloses certain refracting media, for the purpose of bringing rays of light to a focus on the retina; these are the *vitreous* and *aqueous humour*, and the *crystalline lens.*

EXTERNAL TUNIC.—**Sclerotic.**—The sclerotic (σκληρὸς, hard) forms the outer covering of the posterior four-fifths of the globe of the eye. It is continuous posteriorly with the outer sheath of the optic nerve derived from the dura mater, and is pierced by the ciliary nerves and arteries. Anteriorly its fibres are continuous with the transparent ones of the cornea. It is thickest behind, but is strengthened in front by an expansion of the recti tendons, forming the **tunica albuginea**; this is covered for the greater part of its extent by the conjunctiva, and by reason of its brilliant whiteness gives occasion to the common expression, "the white of the eye."

In structure the sclerotic is found to consist of white fibrous tissue, with some few elastic fibres and a great number of stellar nucleated cells; the fibres are arranged in bundles which run both longitudinally and transversely, the superficial layers being chiefly longitudinal. The inner surface of the sclerotic is in contact with the choroid, and is connected to it by means of numerous threads of fibrous tissue and by small vessels; these being tinged with the pigmentary matter of the choroid have a brown appearance, and hence the term **membrana fusca** is applied. At the entrance of the optic nerve a thin cribriform lamella, **lamina cribrosa**,* takes the place of the sclerotic; it is pierced by a number of minute openings for the passage of the nervous filaments, and in the centre by a larger opening called **porus opticus**, for the entrance to the eyeball of the arteria centralis retinæ.

The **cornea** (*corneus*, horny) is the transparent prominent layer which constitutes the anterior fifth of the globe of the eye. It is circular, concavo-convex, and resembles a watch-glass. When examined from the exterior, its vertical diameter is seen to be about one-sixteenth shorter than its transverse, in consequence of the overlapping above and below of the margin of the sclerotic; on the interior its outline is circular. It is continuous with the sclerotic, and is connected with the iris, choroid, and ciliary processes. The thickness of the cornea is from $\frac{1}{32}$ to $\frac{1}{22}$ of an inch; it is generally the same throughout, except at the outer edge, where it becomes a little thinner.

Structure.—The cornea is divisible into four layers; these are, 1. Conjunctival epithelium; 2. Anterior elastic lamina; 3. Cornea propria; and 4. Membrane of Descemet or Demours.

The first of these has been already described. The **anterior elastic lamina** is a transparent and apparently structureless layer, having an average thickness of from $\frac{1}{2000}$ to $\frac{1}{1200}$ of an inch; it is highly elastic, shreds of it curling up immediately when detached. It is connected with the next layer by fine threads which run into the substance of the latter. The **cornea propria** forms the bulk of the cornea. It consists of numerous layers of delicate transparent fibres, which are continuous externally with those of the opaque sclerotic. The fibres are collected into bundles, separated from each other by a ground substance similar to that in other connective tissues. Between the strata nucleated cells are found, which freely anastomose with each other, and appear to be stellate in sections made parallel to the surface of the cornea. The cells lie in spaces in the ground substance, which correspond to them accurately in size and shape. The spaces can be easily made out by painting the tissue with nitrate of silver; they are generally held to be lymph channels. The **membrane of Descemet or Demours** forms the posterior layer of the cornea, and lines the chamber of the aqueous humour; it

* The lamina cribrosa is generally described as the continuation of the sclerotic, but it seems more probable (as Dr. T. Reid suggests) that it is continuous with the choroid; indeed, in an inflamed eyeball the fibres of the lamina have been distinctly traced into the choroid.

consists of an elastic and an epithelial layer. The elastic layer (*posterior elastic lamina* of Bowman) is about $\frac{1}{3000}$ of an inch in thickness, and resembles in all respects the anterior elastic lamina above described. The epithelium consists of a single layer of irregularly shaped nucleated cells. At the edges, the membrane of Descemet breaks up into threads, some of which are continued on to the iris to form the **ligamentum pectinatum,** others terminate in the inner wall of the canal of Fontana, and some few are connected with the ciliary muscle. The processes, which pass to the iris, are covered by a single layer of cells of the same kind as those lining the membrane of Descemet, but, as the cells do not pass over the intervals between the strands, small apertures are left, through which the anterior chamber communicates with the canal of Schlemm.

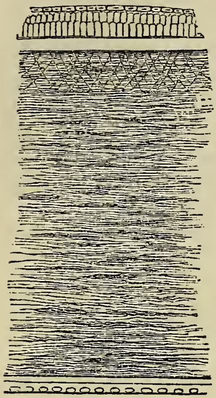


FIG. 327.—A vertical section of the cornea of an adult, showing the layers of which it is composed.

MIDDLE TUNIC.—The second or middle tunic of the eyeball is formed by the *choroid*, *ciliary muscle*, and *iris*, the *ciliary processes* being appendages developed from its inner surface.

The **choroid** (*χόριον εἶδος*, like the chorion, that is to say, "vascular") is of a rich chocolate-brown colour on its external surface, and deep black within. It is connected to the sclerotic by means of the fine areolar tissue called membrana fusca, by vessels and nerves.

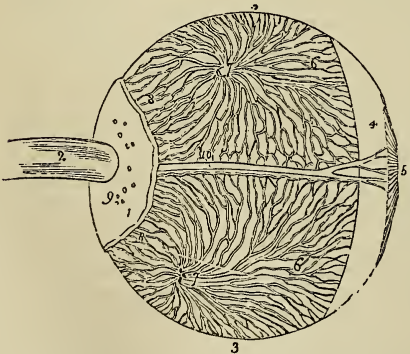


FIG. 328.—Dissection of the eyeball, showing its second tunic, and the mode of distribution of the venæ vorticosæ of the choroid. 1. Part of the sclerotic coat. 2. Optic nerve. 3, 3. Choroid coat. 4. Ciliary ligament. 5. Iris. 6, 6. Venæ vorticosæ. 7, 7. Trunks of the venæ vorticosæ at the point where they have pierced the sclerotic. 8, 8. Posterior ciliary veins, which enter the eyeball in company with the posterior ciliary arteries, by piercing the sclerotic at 9. 10. One of the long ciliary nerves, accompanied by a long ciliary vein.

Internally, it is in simple contact with the retina. It is pierced posteriorly for the passage of the optic nerve, and is connected anteriorly with the iris, ciliary processes, and the line of junction of the cornea and sclerotic.

The choroid is composed of three layers, two of which are vascular, and the third, pigmentary. The **external**, or **venous** layer, consists principally of veins, the smaller branches of which are arranged in whorls (*vasa vorticosa*) round the chief trunks four or five in number. Between the meshes of the veins are stellate pigmentary cells, which are connected together so as to form a fine web. The **middle** or **arterial** layer of the choroid (*tunica Ruyschiana*) is formed principally of the ramifications of minute arteries, which form a complete network with very fine meshes. It is reflected inwards so as to form the ciliary processes.

The *inner* layer (*membrana pigmenti*) consists of cells containing pigment; these are hexagonal in form and are arranged like the tiles of a tesselated pavement. Throughout the whole of the proper choroid these cells are arranged in a single layer, and their nucleus remains clear, but on the ciliary processes and back of the iris there are several layers, and the nuclei of the cells become obscured by the abundance of pigmentary matter. Many authors consider the pigmentary layer as more strictly belonging to the retina than the choroid.

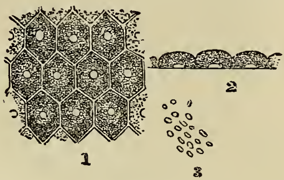


FIG. 329.—Pigmentary layer of the choroid. 1. The cells as seen from the surface. 2. The same viewed edgeways. 3. The fine pigment which fills the cells.

A structureless transparent membrane (*membrane of Bruch*) has been described as lying between the tunica Ruyschiana and the pigmentary layer.

In some animals the pigmentum nigrum of the posterior wall of the eyeball is replaced by a layer of considerable extent, and of metallic brilliance, called **tapetum**; it appears to consist chiefly of white fibrous tissue.

At the junction of the sclerotic and cornea with the choroid and iris, a small venous canal is found, called the **canal of Schlemm or Fontana** (sinus circularis iridis); it communicates with the venous trunks of the choroid, and by the apertures between the strands of the ligamentum pectinatum with the anterior chamber of the aqueous. This canal seems to be more constant in the lower animals than in man, and has been observed to be very large in the negro; its place is frequently taken by several small veins.

The **ciliary muscle** (formerly described as the *ciliary ligament*) is situated internally to the canal of Schlemm. It forms a greyish-white ring round the anterior part of the choroid, and is found to consist of unstriped muscular tissue, the fibres of which are connected in front with the inner surface of the sclerotic, and the fibres of the membrane of Descemet; they pass inwards and backwards, and are attached to the choroid opposite and beyond the ciliary processes. Besides these fibres there are others, situated more internally, at the base of the ciliary processes; these are disposed circularly, and constitute the **circular muscle of Müller** (sphincter

ciliaris). The circular fibres are most developed in hypermetropic eyes, and are very scanty or altogether absent in those which are myopic (Iwanoff).

The **iris** (*iris*, a rainbow) is so named from its variety of colours in different individuals; it consists of muscular and fibrous tissue with pigmentary cells, the latter being interspersed throughout the tissues, as well as forming a distinct posterior layer. The colour of the iris depends on the quantity and arrangement of the pigment cells; when the cells are in small quantity they are chiefly confined to the posterior layers, and the iris as seen from the front has a blue colour; but when in greater quantity, they are also dispersed through the tissues, and a grey or brown colour is the result. By its outer edge the iris is connected with the choroid and sclerotic; by its inner it forms the boundary of a circular opening called the *pupil*; its anterior surface looks towards the cornea and is free; its posterior, looking towards the ciliary processes and lens, is in contact with them throughout greater part of its extent. The stroma of the iris consists of fibres of connective tissue intermixed with cells, the former being arranged radially towards the pupil and circularly near the outer margin.

FIG. 330.—Anterior segment of a transverse section of the globe of the eye, seen from within. 1. Divided edge of the three tunics: sclerotic, choroid (the dark layer), and retina. 2. Pupil. 3. Iris, the surface presented to view in this section being the uvea. 4. Ciliary processes. 5. The scalloped anterior border of the retina.

The muscular tissue is of the unstriped variety. It consists of two sets of fibres, one of which is disposed circularly round the aperture of the pupil, so as to form a sphincter, the contraction of which will diminish the size of the opening; the other set is gathered into numerous bands which radiate from the pupillary margin to the circumference, and serve by their contraction to dilate the pupil.

The pigmentary layer, situated on the posterior surface of the iris, is of a deep purple tint, and hence has received the name of **uvea** (like a grape); it is continuous with the inner layer of the choroid.

On its anterior surface the fibres of the iris have mingled with them some elastic fibres continuous with those of the membrane of Descemet, and are so arranged as to produce a festooned appearance. These festoons are very distinct in the eye of the ox and sheep; they form the **ligamentum pectinatum.** The epithelial cells of

the membrane of Descemet are continued over the anterior surface of the iris.

In the fœtus a delicate vascular membrane closes in the pupil (*membrana pupillaris*); it disappears about the seventh or eighth month.

The **ciliary processes** may be seen in two ways, either by removing the iris from its attachment to the choroid, when a front view of the processes will be obtained, or by making a transverse section through the globe of the eye, when they may be examined from behind, as in fig. 330.

They consist of about eighty triangular folds, about one-third of which are smaller than the rest, and are interspersed at regular intervals. They have the same structure as the choroid, being composed of a vascular network and an internal pigmentary layer.

FIG. 331.—Posterior segment of a transverse section of the globe of the eye, seen from within. 1. Divided edge of the three tunics. The membrane covering the whole internal surface is the retina. 2. The entrance of the optic nerve with the arteria centralis retinæ piercing its centre. 3, 3. Ramifications of the arteria centralis. 4. Foramen of Soemmering, in the centre of the axis of the eye; the shade from the sides of the section obscures the limbus luteus which surrounds it. 5. A fold of the retina, which generally obscures the foramen of Soemmering after the eye has been opened.

Their periphery is connected with the ciliary muscle; the central border is free, and nearly reaches the circumference of the lens; the anterior surface corresponds with the uvea: the posterior surface receives the folds of the suspensory ligament of the lens. Each of the larger folds measures about $\frac{1}{10}$ of an inch in length, and $\frac{1}{40}$ of an inch in depth.

INTERNAL TUNIC.—This consists of the *retina*, with its continuation forwards, called the *pars ciliaris retinæ*.

The **retina** is the inner nervous tunic of the eye, and that on which the images of external objects are produced. It is in contact by its external surface with the pigmentary layer of the choroid, and by its internal surface with the hyaloid membrane of the vitreous humour. It is firmly attached to the back part of the eye by means of the retinal artery and fibres of the optic nerve which enter it, but is loosely applied to the inside of the choroid throughout the rest of its extent. It terminates anteriorly, a little behind the base of the ciliary processes, in a festooned edge, the *ora serrata*; but from this edge there are continued forwards over the ciliary processes to the base of the iris, some peculiar, elongated, nucleated cells, constituting the *pars ciliaris retinæ*.

the continuation of optic nerve —

In the fresh eye the retina is of a pale pink colour, and is translucent, but it soon becomes opaque and yellowish, especially when in contact with fluids. At the back part of the retina, nearly in the axis of the eye, is a spot of a golden-yellow colour—*macula lutea* (called by Soemmering *limbus luteus*); it is elliptical in form, with a long diameter of about $\frac{1}{12}$ of an inch, and short diameter $\frac{1}{30}$ of a inch. In the middle of this is a depression, *fovea centralis*, where, the retina being thinned, the pigmentary matter of the choroid is seen through, hence it has the appearance of being a foramen, and was so described by Soemmering. This is the most sensitive spot of the retina, and being placed nearly in the axis of the eye, receives the image of that part of an object to which the eye is directed, and of which the most vivid impression is obtained.

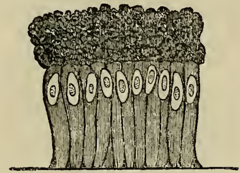


FIG. 332.—Cells of the pars ciliaris retinæ.

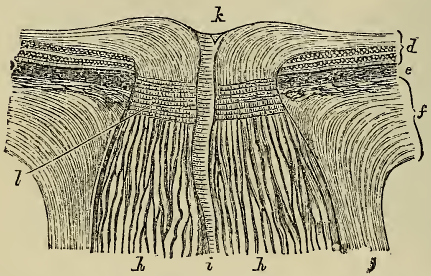


FIG. 333.—Vertical section of the coats of the eye at the point of entrance of the optic nerve. *d.* Retina. *e.* Choroid. *f.* Sclerotic. *g.* Outer sheath of the optic nerve. *h.* Fibres of the optic nerve. *i.* Central artery of the retina. *k.* Its point of subdivision. *l.* Lamina cribrosa.

About $\frac{1}{10}$ of an inch to the inner side of the macula is the entrance of the optic nerve. Here there is a slight elevation (colliculus nervi optici), with a cupped centre, perforated by the arteria centralis retinæ; the artery upon entering immediately breaking up into branches. This is the only part of the retina from which the power of vision is absent. The retina is thickest posteriorly in the immediate vicinity of the optic nerve, where it has a thickness of $\frac{1}{100}$ of an inch, but it thins as it passes forwards, and near the ora serrata measures only $\frac{1}{250}$ of an inch.

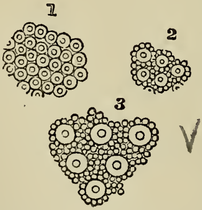


FIG. 334.—Bacillary layer of the retina, seen from the outer surface. 1. In the yellow spot. 2. In the neighbourhood of the yellow spot. 3. Near the ora serrata.

Structure.—The external layer of the retina (*bacillary layer*) was formerly called *Jacob's membrane*, from its having been described by Dr. Jacob; it consists of a number of peculiar rod-like bodies, with which are mingled others with bulbous inner extremities, called *cones.* The relative proportion of **rods** and **cones** differs in different parts of the retina—thus, in the yellow

spot the rods are absent, and the cones are attenuated, elongated, and crowded; in the neighbourhood of the ora serrata, on the other hand, the rods are the most numerous, and the cones are interspersed at considerable intervals (fig. 334).

The middle layer consists of several strata of corpuscles and molecules, which, upon minute examination, are found to be divisible into—(1) an outer stratum, consisting of oval corpuscles of small size, many of which are nucleated (*outer granular layer*); they have been divided into *cone granules* and *rod granules*, according as they are connected with one or other of the elements of the bacillary layer; the former are larger than the latter, and are closely connected to the bases of the cones, while the rod granules are small, transversely striated, and distinct from the bases of the rods; (2) next to this a very narrow band of fine molecules (*outer molecular layer*); and (3) internal to this a layer of larger corpuscles, all of which seem to be nucleated (*inner granular layer*). The granules of the third layer are of two kinds, namely, (α) large cells with two processes or poles; and (β) pale-edged oval nuclei, which are less numerous, and clearly belong to the connective-tissue stroma.

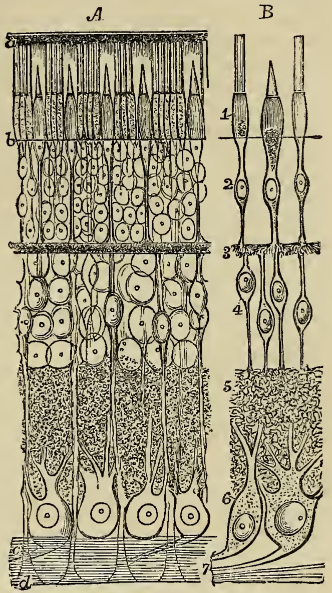


Fig. 335.—Diagram of the structures composing the retina. *A.* The structures viewed *in situ*. *B.* Shows the supposed connection between the components of the several layers. 1. Bacillary layer (rods and cones). 2. Outer granular layer. 3. Outer molecular layer. 4. Inner granular layer. 5. Inner molecular layer. 6. Layer of nerve cells. 7. Layer of nerve fibres. *a.* Pigmentary layer of the choroid. *b.* External limiting membrane. *c.* Connecting trabeculæ (rods of Müller). *d.* Internal limiting membrane.

The inner layer of the retina consists in part of the expanded fibres of the optic nerve, and in part of superadded molecules and nerve cells. Immediately in contact with the inner granular layer above described is a stratum of fine molecules (*inner molecular layer*), and next to this one or two rows of multipolar nerve cells, while, most internally, the fibres of the optic nerve form a thin layer.

These structures are supported by a network of connective tissue, which is condensed so as to form a limiting membrane on the inside of the nerve fibres, and, externally, at the base of the bacillary layer.

Besides the structures above described, there are also in the retina

some peculiar filaments called the **rods of Müller.** These appear to be connected externally with rods and cones; some few have been observed to join the cells of the granular layers, and some have been traced into the internal limiting membrane; these latter, however, are most likely simple filaments of the connective stroma, and not true rods of Müller. It is supposed that these elements connect the rods and cones with the fibres of the optic nerve, being connected intermediately with the cells of the granular layers and the multipolar cells above described; hitherto, however, this complete chain has not been satisfactorily demonstrated.

At the **yellow spot** the retina becomes very much thinned, and the layers of which it is composed are one by one suppressed, until in the centre of the spot only a crowded layer of attenuated cones, a few cells of the outer granular layer, and a few nerve-cells arranged like pavement epithelium, remain. At the entrance of the optic nerve, on the other hand, the bacillary and granular layers are absent, and the layer of nerve cells exists only at the border of the colliculus; the nerve fibres are, however, numerous, and form a very thick layer.

Vessels.—The arteries of the retina are chiefly derived from the arteria centralis retinæ, which enters the eye in the centre of the optic nerve, and breaks up immediately into branches, which ramify for the most part in the inner or nervous layers of the retina, the outer layers being entirely devoid of blood-vessels. The veins have a similar distribution, and terminate in the ophthalmic vein. The optic nerve and its termination, the optic disc, receive only a few very fine branches from the arteria centralis, being chiefly supplied by vessels running inside the sheath and derived from the short ciliary arteries.

The **refracting media** of the eye are the *aqueous* and *vitreous humours*, and the *lens;* but in conjunction with these we shall also describe the *suspensory ligament* and *capsule of the lens*, as well as the *canal of Petit.*

The **aqueous humour** fills up the space between the cornea and the capsule of the lens with its suspensory ligament; it is a weakly albuminous fluid, with an alkaline reaction, and a specific gravity very little greater than that of water. The *anterior chamber* is the space intervening between the cornea in front, and the iris and pupil behind. The *posterior chamber* was formerly described as the space between the posterior surface of the iris and pupil in front, and the ciliary processes, suspensory ligament, and lens behind,—but it is now known that the iris at the edge of the pupil is in absolute contact with the capsule of the lens, so that the term must be restricted to the triangular interval existing between the ciliary processes, suspensory ligament, and iris, at the attached margin of the latter.

The **vitreous humour** forms the principal bulk of the globe of the eye, and supports the delicate retina internally. It is a transparent and highly albuminous fluid, enclosed in a delicate homogeneous membrane, the **hyaloid membrane.** Hannover supposed

that septa of the hyaloid membrane also formed cavities for the contained fluid, but microscopic examination has shown that such is not the case in the adult, though there undoubtedly are fibres in the centre of the vitreous in the fœtus. Scattered through its substance are a number of corpuscles of various shapes and sizes, many exhibiting amœboid movements, and near the periphery stellate and spindle-shaped cells have been described. The centre of the vitreous is traversed by a minute canal (*canal of Stilling*) extending from the optic-nerve entrance to the back of the lens; it is filled with clear fluid. Anteriorly the hyaloid is connected with the posterior part of the capsule of the lens, and forms the back of the canal of Petit—while a thickened prolongation of it forms the suspensory ligament of the lens.

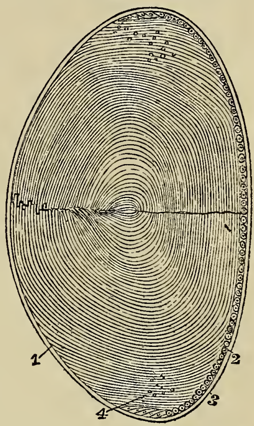


FIG. 336.—The crystalline lens. 1. The laminæ of which the lens is composed. 2. The cells contained between the capsule and front of the lens. 3. Capsule of the lens. 4. Nuclear zone.

The **crystalline lens** is situated immediately behind the pupil, and surrounded by the ciliary processes, which nearly reach its margin. It is more convex on its posterior than its anterior surface, and is embedded in the anterior part of the vitreous humour, from which it is separated by the hyaloid membrane. It is invested by a peculiar transparent and elastic membrane, the *capsule of the lens*, which is thicker in front than behind, in consequence of the suspensory ligament joining it on that aspect. The capsule is connected with the lens in front by means of a single layer of "granular and nucleated polygonal cells," which, at its edge, become continuous with the nucleated fibres of the lens itself (fig. 336). The lens is retained in its place by means of the suspensory ligament, to be presently described.

Structure.—The lens consists of concentric layers, of which the external are soft, the next firmer, and the central form a hardened nucleus. They are best demonstrated by boiling or by immersion in alcohol, when they are easily separated from each other. Another division of the lens takes place at the same time: it splits into three triangular segments, having the sharp edge directed towards the centre, and the base towards the circumference. The concentric laminæ are composed of minute hexagonal fibres, united with each other by means of irregularly serrated edges, the serrations of which accurately fit into each other. Some of the superficial fibres possess nuclei, which are usually arranged in regular zones, and are continuous in series with the nuclei of the cells between the capsule and lens anteriorly (Babuchin).

The **suspensory ligament of the lens**—Retzius (Zonule of Zinn, Zonula ciliaris)—is a firm, transparent membrane, which passes from the fore part of the circumference of the lens to join the hyaloid membrane nearly opposite the ora serrata. It is gathered up into numerous plaits which fit into the depressions between the ciliary processes, and when withdrawn carry with them some of the pigment which covers those processes. Structurally, it is found to consist of pale longitudinal parallel fibres, which resemble those of elastic tissue.

Immediately around the circumference of the lens is a triangular canal, the **canal of Petit**, about a line and a half in breadth. It is bounded in front by the suspensory ligament; behind by the hyaloid membrane; and within by the border of the lens.

VESSELS AND NERVES OF THE GLOBE OF THE EYE.

The *vessels* of the globe of the eye are the long, short, and anterior ciliary arteries, and the *arteria centralis retinæ.*

The **long ciliary arteries**, two in number, pierce the posterior part of the sclerotic, and pass forwards on each side, between that membrane and the choroid, to the base of the ciliary processes, where each divides into two branches, which form an elaborate network in the substance of the ciliary processes and iris. The **short ciliary arteries** pierce the posterior part of the sclerotic coat, and are distributed to the middle layer of the choroid membrane (tunica Ruyschiana).

The **anterior ciliary** are branches of the muscular arteries; they enter the eye just behind the junction of the cornea and sclerotic, and join the anastomotic circle of the iris. It is the congestion of these latter arteries, in iritis, that gives rise to the peculiar red zone round the circumference of the cornea. The distribution of the **arteria centralis retinæ** has been already described.

The **nerves** of the eyeball are—the optic, two ciliary nerves from the nasal branch of the ophthalmic, and the ciliary nerves from the ophthalmic ganglion. The optic nerve has an outer sheath continuous with the sclerotic and derived from the dura mater, and an inner sheath which it receives from the arachnoid. Between these is the *subvaginal space*, continuous with the subdural space of the cranial cavity.

DEVELOPMENT OF THE EYE.

The important circumstance to note in connection with the development of the eye is—that whereas the globe of the eye and the vitreous humour are formed from those small lobes given off from the anterior cerebral vesicle, and known as the optic lobes—the anterior part of the eye, including the crystalline lens, cornea, and iris, is developed from the integumentary structures of the face.

ORGAN OF HEARING.

The apparatus of hearing is composed of three parts, external ear, middle ear or tympanum, and internal ear or labyrinth.

EXTERNAL EAR.

The external ear consists of two portions, the **pinna** and **meatus**: the former representing a kind of funnel which collects the vibrations of the atmosphere producing sounds, and the latter a tube which conveys the vibrations to the tympanum.

The **PINNA** presents a number of folds and hollows on its surface, which have different names assigned to them. Thus, the external folded margin is the **helix** (ἕλιξ, a fold). The elevation parallel with and in front of the helix, is the **antihelix** (ἀντὶ, opposite). The pointed process, projecting like a valve over the opening of the ear, from the face, is the **tragus** (τράγος, a goat), probably from being sometimes covered with bristly hair like that of a goat; and a tubercle opposite this is the **antitragus.** The lower dependent and fleshy portion of the pinna is the **lobulus.** The space between the helix and antihelix is named the **fossa of the helix** (*scaphoid or innominate fossa*). Another depression at the upper extremity of the antihelix, produced by a bifurcation of that ridge, is the **fossa of the antihelix** (*oval or triangular fossa*); and the large central space, to which all the channels converge, the **concha**, which opens directly into the **meatus.**

The pinna is composed of *integument*, *fibro-cartilage*, *ligaments*, and *muscles.*

The **integument** is thin, contains an abundance of sebaceou glands, and is closely connected with the fibro-cartilage.

The **fibro-cartilage** gives form to the pinna, and is folded so as to produce the various convexities and grooves which have been described on its surface. The **helix** begins in the concha, and partially divides that cavity into two parts; on its anterior border, where it commences its curve upwards, is a tubercle or spine, and a little above this a small vertical fissure, the **fissure of the helix.** The termination of the helix and antihelix forms a lengthened process, the **processus caudatus,** which is separated from the concha by an extensive fissure. On the anterior surface of the tragus is another fissure, the **fissure of the tragus**; and, in the lobulus, the fibro-cartilage is wanting. The fibro-cartilage of the meatus is divided from the concha by several fissures (fissures of Santorini), and at the upper and anterior part of the cylinder is a considerable space, which is closed by muscular and ligamentous fibres; it is firmly attached at its termination to the processus auditorius.

The **ligaments** of the external ear are those which attach the pinna to the side of the head—viz., anterior, posterior, and ligament

of the tragus; and those of the fibro-cartilage, which serve to preserve its folds and connect the opposite margins of the fissures. The latter are two in number, the ligament between the concha and processus caudatus, and the broad ligament which extends from the upper margin of the fibro-cartilage of the tragus to the helix, and completes the meatus.

The proper **muscles** of the pinna are the—

Major helicis,	Antitragicus,
Minor helicis,	Transversus auriculæ,
Tragicus,	Obliquus auris.

The **major helicis** is a narrow band of muscular fibres situated on the anterior border of the helix. It arises from the spine of the helix, and is inserted into the anterior border of that fold.

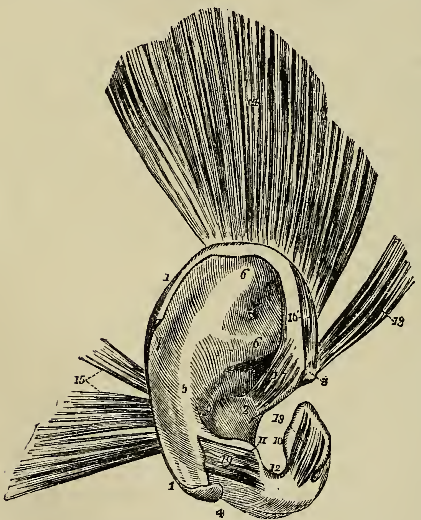


FIG. 337.—The pinna and its muscles. 1, 1. Helix. 2. Crus helicis. 3. Spina helicis. 4. Processus caudatus helicis. 5. Antihelix. 6, 6. Crura antihelicis. 7. Fossa of the helix (scaphoid fossa). 8. Fossa of the antihelix (triangular fossa). 9. Concha. 10. Tragus. 11. Antitragus. 12. Incisura intertragica. 13. Attrahens auriculam. 14. Attollens auriculam. 15. Retrahens auriculam. 16. Major helicis muscle. 17. Minor helicis. 18. Tragicus. 19. Antitragicus.

The **minor helicis** is placed upon the anterior extremity (crus) of the helix, at its commencement in the fossa of the concha.

The **tragicus** is a thin quadrilateral layer of muscular fibres, situated on the tragus, and having a vertical direction.

The **antitragicus** arises from the antitragus, and is inserted into the posterior surface of the processus caudatus of the helix.

The **transversus auriculæ**, partly tendinous and partly muscular, extends transversely from the convexity of the concha to that of the helix, on the posterior surface of the pinna.

The **obliquus auris** (Tod) is a small band of fibres passing between the upper part of the convexity of the concha and the convexity immediately above it.

Dissection.—In the recent temporal bone the external auditory meatus may be examined by cutting away with the saw the squamous

portion of the bone in front of the fissure of Glaser, and then removing with bone forceps the anterior wall of the meatus, excepting the portion which supports the membrana tympani.

The **MEATUS AUDITORIUS** is a canal, partly cartilaginous and partly osseous, about an inch in length, which extends inwards and a little forwards from the concha to the tympanum. It is narrower in the middle than at each extremity, forms an oval cylinder, the long diameter being vertical, is directed a little forwards, and is slightly curved on itself, the concavity looking downwards. In consequence of the obliquity of the membrana tympani, the floor of the canal is a little longer than its roof.

The cartilaginous portion of the tube forms a little less than half the passage. The osseous portion has been described in connection with the temporal bone. The skin of the meatus is very thin, especially towards the bottom of the passage; after maceration in water, the epithelial lining frequently comes away as a complete and very delicate pouch. Some stiff short hairs are also found in its interior, which stretch across the tube, and prevent the ingress of insects and dust. In the substance of its lining membrane are a number of *ceruminous glands*, which secrete the wax of the ear.

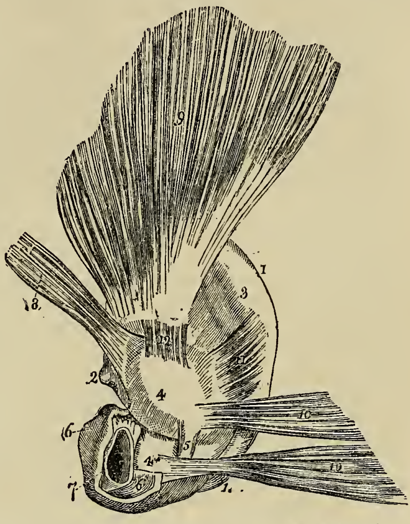


FIG. 338.—The pinna and its muscles, as seen from behind. 1, 1. Border of the helix. 2. Spine of the helix. 3. Convexity corresponding with the fossa of the helix. 4, 4. Convexity of the concha; the fissure between the numbers corresponds with the crus helicis. 5. Ponticulus conchæ. 6, 6. Cartilage of the meatus. 7. Aperture of the meatus. 8. Attrahens auriculam. 9. Attollens auriculam. 10. Retrahens auriculam. 11. Transversus auriculæ. 12. Obliquus auriculæ.

Vessels and Nerves.—The pinna is plentifully supplied with *arteries*; by the anterior auricular from the temporal, by the posterior auricular from the external carotid, and by a branch from the occipital artery.

Its **nerves** are derived from the auriculo-temporal of the fifth, the posterior auricular of the facial, and the auricularis magnus of the cervical plexus.

MIDDLE EAR OR TYMPANUM.

Dissection.—In a fresh specimen in which the meatus has been displayed in the manner above described, it is only necessary to remove with bone forceps the roof of the tympanum, taking care to avoid injuring the membrana tympani, chorda tympani nerve, and chain of small bones.

The **tympanum** is an irregular cavity hollowed out in the base of the petrous bone, and placed between the membrana tympani externally and the labyrinth within. It is narrow below and in front, and wider above and behind, and communicates behind with the mastoid cells, internally with the vestibule and scala tympani, and in front by means of the Eustachian tube with the pharynx. It is described as having a *roof* (tegmen tympani) and a *floor*, the former consisting of a thin plate of bone separating the cavity from the middle fossa of the skull, and the latter being formed by the roof of the jugular fossa. The *outer wall* corresponds throughout greater part of its extent to the membrana tympani and the ring of bone surrounding it; in front of the latter is the irregular slit called *fissure of Glaser*, which gives passage to the laxator tympani muscle and anterior tympanic artery, and in infancy lodges the long process of the malleus (processus gracilis); at the inner extremity of this fissure is a small canal (canal of Huguier) which gives passage to the chorda tympani nerve. The *inner wall* separates the cavity of the tympanum from the internal ear; it is rough and irregular, and is more extensive than the outer wall. It is marked at its upper part by a ridge formed by the aquæductus Fallopii; beneath this is an oval opening, *fenestra ovalis*, which lodges the foot of the stapes; next a rounded prominence due to the projection of the first turn of the cochlea, and called the *promontory;* and below this, near the floor of the cavity, a circular opening, *fenestra rotunda*, which communicates with the scala tympani of the cochlea. At the back part of this wall, behind the fenestra ovalis, is a conical projection named the *pyramid;* it contains the stapedius muscle, the tendon of which escapes through a small opening near its summit. The *posterior wall* is irregular, and has several small openings which communicate with the mastoid cells. The *anterior extremity* is narrow, and has opening into it two canals separated by a lamella of bone (processus cochleariformis), the lower and larger being the commencement of the Eustachian tube, and the upper and smaller containing the tensor tympani muscle.

The cavity of the tympanum is lined by mucous membrane continuous with that of the Eustachian tube and pharynx: it covers the walls of the cavity including the membrana tympani, is reflected over the ossicles and chorda tympani nerve, and is continued into the mastoid cells to form their lining membrane. The epithelium is for the most part columnar and ciliated, but the roof, promontory, ossicles, and membrana tympani are covered by flattened non-ciliated cells.

The **membrana tympani** is a thin and semi-transparent membrane of an oval shape, its long diameter being vertical. It is inserted into a groove situated around the circumference of the meatus, near its termination, and is placed obliquely across the area of that tube, the direction of the obliquity being downwards and inwards. It is concave towards the meatus, convex towards the tympanum, and composed of *three layers : external*, or epithelial, continuous with the integument of the meatus ; *middle*, fibrous, the fibres of which radiate from the handle of the malleus ; and *internal*, mucous, derived from the mucous lining of the tympanum.

The tympanum contains three small bones, **ossicula auditûs**—viz., the malleus, incus, and stapes.

The **malleus** (*hammer*) consists of a head, neck, handle (*manubrium*), and two processes, *long* (*processus gracilis*), and *short* (*processus brevis*). The manubrium is connected with the membrana tympani by its whole length, extending below the central point of that membrane. It lies beneath the mucous layer of the membrane, and serves as a point of attachment to which the radiating fibres of the fibrous layer converge. The long process descends in the young child to the fissure of Glaser, and gives attachment to the laxator tympani muscle ; in the adult it is in great measure converted into ligamentous tissue, hence it no longer deserves the title of processus gracilis, and Helmholtz proposes to call it *processus Folianus*. The

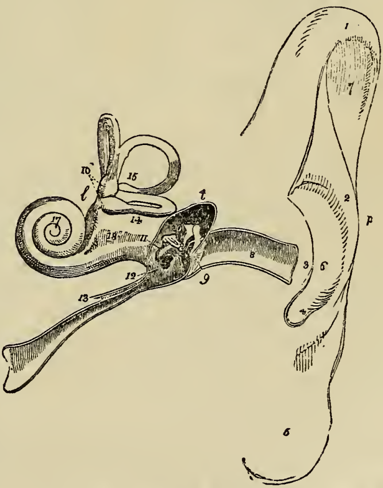


FIG. 339.—Diagram of the ear. *p*. Pinna. *t*. Tympanum. *l*. Labyrinth. 1. Upper part of the helix. 2. Antihelix. 3. Tragus. 4. Antitragus. 5. Lobule. 6. Concha. 7. Upper part of the fossa of the antihelix. 8. Meatus. 9. Membrana tympani, divided by the section. 10. The three little bones, crossing the area of the tympanum—malleus, incus, and stapes ; the foot of the stapes blocks up the fenestra ovalis of the inner wall of the tympanum. 11. Promontory. 12. Fenestra rotunda ; the dark opening above the ossicula leads into the mastoid cells. 13. Eustachian tube ; the little canal upon this tube contains the tensor tympani muscle in its passage to the tympanum. 14. Vestibule. 15. Three semicircular canals, horizontal, perpendicular, and oblique. 16. Ampullæ of the perpendicular and horizontal canal. 17. Cochlea. 18. Depression between the two tubuli which communicate with the tympanum and vestibule ; the one is the scala tympani, terminating at 12 ; the other the scala vestibuli.

short process is a conical elevation at the junction of the manubrium with the rest of the bone; into it is inserted the tendon of the tensor tympani. The head of the bone articulates with the incus.

The **incus** (*anvil*) is named from an imagined resemblance to an anvil. It has also been likened to a bicuspid tooth, having one root longer than, and widely separated from, the other. It consists of two processes, united nearly at right angles, and at their junction forming a flattened body, which articulates with the head of the malleus. The short process is attached to the margin of the opening of the mastoid cells by means of a ligament; the long process descends nearly parallel with the handle of the malleus, and curves inwards near its termination. At its extremity is a small globular projection, the **os orbiculare**, which in the fœtus is a separate piece, but becomes anchylosed to the long process of the incus in the adult; this process articulates with the head of the stapes.

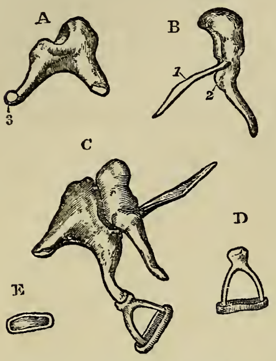


Fig. 340.—Small bones of the tympanum. A. Incus. B. Malleus. C. The three bones articulated. D. Stapes. E. The foot of the stapes. 1. Processus gracilis of the malleus. 2. Processus brevis. 3. Os orbiculare.

The **stapes** is shaped like a stirrup, to which it bears a close resemblance. Its head articulates with the os orbiculare, and the two branches (crura) are connected by their extremities with a flat, oval-shaped plate, representing the foot of the stirrup. The foot of the stirrup is received into the fenestra ovalis, to the margin of which it is connected by means of a ligament; it is in contact, by its surface, with the membrana vestibuli, and is covered in by the mucous lining of the tympanum. The neck of the stapes gives attachment to the stapedius muscle.

The ossicula auditûs are retained in position and moved upon themselves by means of ligaments and muscles.

The **ligaments** are four in number; the *suspensory ligament of the malleus*, which is attached by one extremity to the upper wall of the tympanum, and by the other to the head of the malleus; the *anterior ligament of the malleus*, a broad and strong band which connects the anterior wall of the tympanum with the malleus, in a line extending from the base of the processus Folianus to the head; the *posterior ligament of the incus*, a short and thick band, which serves to attach the extremity of the short process of that bone to the margin of the opening of the mastoid cells; and the *annular ligament* which connects the margin of the foot of the stapes with the circumference of the fenestra ovalis; it is continuous with the periosteum of the vestibular wall and with that covering the foot of the stapes.

Between the head of the malleus and the incus, and between the incus and stapes, there are distinct joints; the bones being united by ligaments, the osseous surfaces coated with cartilage, and the joints lined by complete synovial membranes.

The **muscles of the tympanum** are four in number, the—

Tensor tympani,	Laxator tympani minor,
Laxator tympani,	Stapedius.

The **tensor tympani** *arises* from the spinous process of the sphenoid, the petrous portion of the temporal bone and the Eustachian tube, and passes forwards in a distinct canal, separated from the tube by the processus cochleariformis, to be *inserted* into the inner part of the handle of the malleus near its base.

The **laxator tympani** *arises* from the spinous process of the sphenoid bone, and passes through an opening in the fissure of Glaser, to be *inserted* into the neck of the malleus, just above the root of the processus gracilis. This is regarded as a ligament by some anatomists.

The **laxator tympani minor** (posterior ligament of the malleus) *arises* from the upper margin of the meatus, and is *inserted* into the handle and processus brevis of the malleus. This is regarded as a ligament by some anatomists.

The **stapedius** *arises* from the interior of the pyramid, and descending part of the aquæductus Fallopii; it becomes tendinous, and escapes from the summit of the pyramid to be *inserted* into the neck of the stapes.

Actions.—The action of the tensor and laxator tympani muscles is sufficiently indicated by their names, but that of the stapedius is more difficult to understand. It seems, however, evident that by its contraction it will tend to pull the foot of the stapes out of the fenestra ovalis, and may thus prevent too forcible excitation of the delicate internal ear. The stapedius is supplied by a branch from the facial nerve, and it is noteworthy that in cases of intra-cranial paralysis of the facial there is often intolerance of loud sounds.

Foramina.—The openings in the tympanum are ten in number, *five large* and *five small*; they are—

Large Openings.	**Small Openings.**
Meatus auditorius,	Entrance of chorda tympani,
Fenestra ovalis,	Exit of chorda tympani,
Fenestra rotunda,	For the laxator tympani,
Mastoid cells,	For the tensor tympani,
Eustachian tube.	For the stapedius.

The opening of the **meatus auditorius** has been already described.

The **fenestra ovalis** (fenestra vestibuli) is a reniform opening, situated at the bottom of a small oval fossa (pelvis ovalis), in the upper part of the inner wall of the tympanum, directly opposite the

meatus. The long diameter of the fenestra is horizontal, and its convex borders directed upwards. It is the opening of communication between the tympanum and vestibule, and is closed by the foot of the stapes and by the lining membrane of both cavities.

The **fenestra rotunda** (fenestra cochleæ) is somewhat triangular in form, and situated in the inner wall of the tympanum, below and rather posteriorly to the fenestra ovalis, from which it is separated by a bony elevation, called the **promontory**; it lies at the bottom of a funnel-shaped depression, and serves to establish a communication between the tympanum and cochlea. In the fresh subject it is closed by a proper membrane (m. tympani secundaria) as well as by the lining of both cavities.

The **mastoid cells** are numerous, and occupy the whole of the interior of the mastoid process and part of the petrous bone. They communicate by a large irregular opening with the upper and back part of the tympanum.

The **Eustachian tube** is a short canal about an inch and three-quarters in length, extending obliquely between the pharynx and the anterior circumference of the tympanum. It is directed downwards, forwards, and inwards, and opens anteriorly, behind the inferior meatus of the nose, into the pharynx. It consists of an osseous and a fibro-cartilaginous portion, the former of which has been already described in connection with the temporal bone. The cartilage of the Eustachian tube is of a triangular form, having its inferior angles rolled up towards each other, but leaving between them a gap on the under side, which is filled up with fibrous tissue. The tube is narrow where it opens into the tympanum, but expands anteriorly, so as to become wide and trumpet-shaped.

The **smaller openings** serve for the transmission of the chorda tympani nerve, and three of the muscles of the tympanum.

The *opening* by which the *chorda tympani* enters the tympanum is at about the middle of its *posterior wall*, and near the root of the pyramid. The *opening of exit* for the chorda tympani is at the inner end of the fissure of Glaser in the *outer wall* of the tympanum. The nerve is usually contained in a canal (called the *canal of Huguier*) distinct from the fissure of Glaser.

The *opening* for the *laxator tympani* muscle is situated in the fissure of Glaser, in the *outer wall* of the tympanum. The *opening* for the *tensor tympani* muscle is in the *anterior wall*, immediately below the opening of the Eustachian tube. The *opening* for the *stapedius* muscle is at the apex of a conical bony eminence, the pyramid, which is situated at the back part of the *inner wall* of the tympanum, immediately behind the fenestra ovalis.

Directly *above* the fenestra ovalis is a *rounded ridge* formed by projection of the *aquæductus Fallopii. Beneath* the fenestra ovalis and separating it from the fenestra rotunda is the *promontory*, a rounded prominence formed by the projection of the first turn of the cochlea. It is channelled on its surface by three small grooves which lodge the three tympanic branches of Jacobson's nerve.

The **foramina** and **processes of the tympanum** may be arranged, according to their situation, into four groups :—

1. In the **external wall**, from above downwards, are the—
   Meatus auditorius, closed by the membrana tympani,
   Fissure of Glaser,
   Canal of Huguier.

2. In the **inner wall** are the—
   Ridge of the aquæductus Fallopii,
   Fenestra ovalis,
   Pyramid,
   Promontory, with the grooves for nerves,
   Fenestra rotunda.

3. In the **posterior wall** are the—
   Opening of the mastoid cells,
   Opening for Jacobson's nerve,
   Opening of entrance of chorda tympani.

4. In the **anterior wall** are the—
   Canal for tensor tympani muscle,
   Eustachian tube.

Vessels and Nerves.—The *arteries* of the tympanum are the anterior tympanic from the internal maxillary, the tympanic from the internal carotid, the stylo-mastoid from the posterior auricular, and the petrosal from the middle meningeal; occasionally there is also a small branch of the ascending pharyngeal, which ascends by the side of the Eustachian tube to reach the tympanum. The *veins* terminate in the middle meningeal and pharyngeal veins, which form a plexus near the articulation of the lower jaw, and empty into the internal jugular vein.

The *nerves* are—1. Minute branches of the facial distributed to the stapedius muscle. 2. The *chorda tympani* nerve, which leaves the facial nerve near the stylo-mastoid foramen, and arches upwards to enter the tympanum at the root of the pyramid ; it then passes forwards between the handle of the malleus and long process of the incus to reach the canal of Huguier, through which it escapes. 3. The *tympanic plexus*, formed by the tympanic branch of the glosso-pharyngeal (Jacobson's nerve), filaments from the carotid plexus, the lesser petrosal nerve from the otic ganglion, and a branch from the greater petrosal nerve. The branches of the plexus lie in shallow grooves on the surface of the promontory, and contain numerous ganglion cells, both in the course of the filaments and at the points where they unite ; they are distributed to the mucous membrane of the tympanum, Eustachian tube, and mastoid cells. 4. A filament from the otic ganglion to the tensor tympani muscle.

INTERNAL EAR.

The internal ear is called the **labyrinth**, from its complexity; it consists of an osseous cavity and certain membranous structures contained therein, the latter constituting the membranous labyrinth.

The **OSSEOUS LABYRINTH** presents a series of cavities, which are channelled in the substance of the petrous portion of the temporal bone, and is situated between the cavity of the tympanum and the meatus auditorius internus. It is divided into three unequal portions; these are the—

Vestibule, Semicircular canals, Cochlea.

The **vestibule** is the central part of the osseous labyrinth; it is irregularly ovoid in shape, and a little flattened from without inwards. In front it communicates with the cochlea, and behind with the semicircular canals; its outer wall separates it from the cavity of the tympanum, and its inner wall corresponds to the bottom of the meatus auditorius internus.

In the outer wall there is seen the reniform opening of the fenestra ovalis, the margin of which presents a prominent ring towards the vestibule; it is closed in the recent state by the foot of the stapes and its annular ligament, as well as by the lining membrane of the labyrinth and a special membrane (membrana secundaria).

In the anterior part of the inner wall is a circular depression which corresponds to the posterior segment of the cul-de-sac of the internal meatus; it is called *fovea hemispherica*, and is pierced by a cluster of openings (*macula cribrosa*) through which pass filaments of the vestibular branch of the auditory nerve, and twigs of the auditory artery. Behind this is a small ridge (*crista vestibuli*), and the commencement of a small canal called the *aquæductus vestibuli*, containing a tubular membranous sheath and a small vein.

In the roof is another depression of oval form called *fovea hemi-elliptica;* it is separated from the fovea hemispherica by a slight ridge.

Posteriorly, the five openings of the three semicircular canals are observed, the oblique and perpendicular canals joining by one extremity and so entering by a common opening.

In front the vestibule opens into the cochlea by means of a wide, funnel-shaped opening, called *apertura scalæ vestibulæ.*

The openings of the vestibule may be arranged, like those of the tympanum, into *large* and *small.*

The large openings are seven in number:—

Fenestra ovalis,
Apertura scalæ vestibuli,
Five openings of the semicircular canals.

The small openings are three :—

Aquæductus vestibuli,
Openings for small arteries,
Openings for filaments of the auditory nerve.

The **SEMICIRCULAR CANALS** are three bony passages communicating with the vestibule, into which they open by both their extremities. Near one extremity of each of the canals is a dilatation of its cavity which is called an *ampulla.*

1. The **superior** or **perpendicular** canal is directed transversely across the petrous bone, and forms that prominence on its anterior surface which we have already described. It commences by means of an ampulla in the upper part of the vestibule, and terminates posteriorly by joining with the oblique canal, and forming a common canal which opens into the back part of the vestibule.

2. The **posterior** or **oblique** canal corresponds with the posterior part of the petrous bone; it commences by an ampullary dilatation in the posterior part of the vestibule, and curves nearly perpendicularly upwards to terminate in the common canal. In the ampulla of this canal are numerous openings for nervous filaments.

3. The **external** or **horizontal** canal is directed outwards towards the base of the petrous bone, and is shorter than the two preceding. It commences by an ampullary dilatation above the fenestra ovalis, and terminates near to the common canal.

The **COCHLEA** (so called from its resemblance to a snail's shell) is the most anterior part of the labyrinth, corresponding by its apex with the anterior wall of the petrous bone, and by its base with the anterior depression at the bottom of the cul-de-sac of the meatus auditorius internus. Its apex is arched so as to form a sort of dome, which is called the *cupola.*

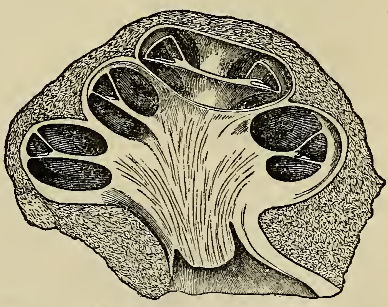


Fig. 341.—Vertical section of the cochlea of a calf, showing the modiolus and scalæ.

It consists of a gradually tapering canal, about one inch and a half in length, which makes two turns and a half around a central axis called the *modiolus*. The first coil projects into the tympanum, forming that rounded elevation which has already been described as the *promontory.*

The **central axis** or **modiolus** is large near its base, where it corresponds to the first turn of the cochlea, but diminishes as it proceeds towards the apex. Its external surface is composed of dense tissue, but its interior is spongy, and is pierced by numerous canals, which run spirally in its length, transmitting the filaments

of the cochlear nerve. The central canal is usually larger than the others; it transmits the artery of the modiolus as well as a nerve, and is called *tubulus centralis modioli.*

The interior of the canal of the cochlea is partially divided into two passages or **scalæ** by means of a thin and porous lamina of bone, the **lamina spiralis ossea**, which is wound spirally round the modiolus in the direction of the canal. It extends about two-thirds across the diameter of the canal, and consists of two thin lamellæ, between which, and through the perforations on their surfaces, the filaments of the cochlear nerve reach the membranous portion of the cochlea. The upper of the two passages thus separated is called the **scala vestibuli**, the lower the **scala tympani.**

At the apex of the cochlea the osseous lamina terminates by a hook-shaped process (*hamulus laminæ spiralis*); and here also the scalæ communicate by means of a small opening called the **helicotrema.** Inferiorly, one of the two scalæ, the scala vestibuli, terminates by an oval aperture in the anterior part of the vestibule; while the other, the scala tympani, becomes somewhat expanded, and opens into the tympanum through the fenestra rotunda.

The internal surface of the osseous labyrinth is lined by a thin layer of periosteum which is separated from the membranous structures contained in its cavities by a limpid fluid called the **perilymph** (liquor Cotunnii). In the cochlea the periosteum invests the two surfaces of the bony lamina spiralis. The fenestra ovalis and fenestra rotunda are closed by an extension of this membrane across them, assisted by the membrane of the cavity of the tympanum, and a proper intermediate layer (*membrana secundaria*). Besides lining the interior of the osseous cavity, the periosteum sends two delicate processes along the aqueducts of the vestibule and cochlea, to the dura mater, with which they are continuous. These processes are the remains of a communication originally existing between the dura mater and the cavity of the labyrinth.

MEMBRANOUS LABYRINTH.—This consists of certain membranous bags contained within the osseous cavity of the vestibule and semicircular canals, and of the structures which serve to complete the spiral lamina of the cochlea.

The membranous labyrinth of the semicircular canals and vestibule has the same general shape as the osseous cavity in which it is contained; it floats in the perilymph, and is held in position by numerous nerve filaments derived chiefly from the vestibular wall, and by fine fibrous bands derived from the periosteum of the osseous labyrinth. It contains in its interior a fluid similar to the perilymph, which is called **endolymph,** and is secreted by its lining membrane.

Structure.—In structure this part of the membranous labyrinth consists of three layers—an *outer*, fibrous; a *middle*, homogeneous (tunica propria); and an *inner*, epithelial. The *fibrous* layer consists of connective tissue containing some scattered pigment cells; it is connected with the periosteum by well-marked fibrous bands along which

blood-vessels run. The *tunica propria* is transparent and apparently structureless, and is thinnest where the membranous tube is in contact with the osseous wall; it presents towards the cavity of the tube a number of papillary projections covered by the cells of the inner coat. The *epithelial* layer is formed throughout of a single layer of flattened cells. In the ampullæ the tunica propria is very thick, and causes the wall to project into the cavity in the form of a transverse partition (septum transversum); on this septum the epithelial cells are columnar, and surmounted by fine but stiff hair-like processes (fila acoustica).

The **membranous vestibule** consists of two sacs, a greater and a lesser. The greater sac, called the **utricle** (sacculus communis), rests in the depression called fovea hemi-elliptica, in the upper and back part of the vestibule; it is oblong and slightly flattened from within outwards. Its inner wall is thickened, where it receives numerous

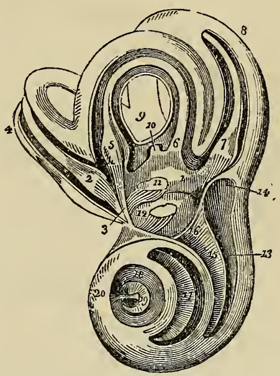


FIG. 342.—Labyrinth of the left ear showing its cavities and the membranous labyrinth; 1. Cavity of the vestibule; the figure rests on the utricle. 2. Ampulla of the perpendicular semicircular canal, receiving a fasciculus from the superior branch of the vestibular nerve (3). 4. Perpendicular canal with its contained membranous canal. 5. Ampulla of the horizontal semicircular canal, receiving a fasciculus from the superior branch of the vestibular nerve. 6. Termination of the membranous canal of the horizontal semicircular canal, in the utricle. 7. Ampulla of the oblique semicircular canal, receiving a fasciculus from the inferior branch of the vestibular nerve. 8. Oblique semicircular canal with its membranous canal. 9. The common canal, resulting from the union of the perpendicular with the oblique semicircular canal. 10. Membranous common canal terminating in the utricle. 11. The otolith of the utricle seen through the membranous parietes. A fasciculus from the inferior branch of the vestibular nerve distributed to the utricle near the otolith. 12. Sacculus; its otolith is seen through its membranous parietes, and a fasciculus derived from the middle branch of the vestibular nerve is distributed to it. 13. First turn of the cochlea; the figure points to the scala tympani. 14. Extremity of the scala tympani, the fenestra rotunda. 15. Lamina spiralis; the figure is situated in the scala vestibuli. 16. Opening of the scala vestibuli into the vestibule. 17. Second turn of the cochlea; the figure is placed on the lamina spiralis, and therefore in the scala vestibuli, the scala tympani being beneath the lamina. 18. Remaining half-turn of the cochlea; the figure is placed in the scala tympani. 19. Lamina spiralis terminating in its falciform extremity. The dark space included within the falciform curve of the extremity of the lamina spiralis is the helicotrema. 20. Infundibulum.

branches of the vestibular nerve. Firmly attached to the wall of the utricle, is a small aggregation of crystals of carbonate of lime; these are irregular in shape, and are called *otoliths* (ear-stones), or *otoconia* (ear-dust). The cavity of the utricle is continuous with that of the membranous semicircular canals, but is distinct from that of the saccule.

The lesser sac, called the **saccule** (sacculus proprius), is spherical

in shape, and is situated in the lower and anterior part of the vestibule, lying in the depression of the fovea hemispherica. It receives nerves through the lamina cribrosa, and contains otoliths similar to those of the utricle. It is connected by means of a minute passage (*canalis reuniens*), with a small canal, which is contained within the membranous part of the cochlea, and is called *scala media;* it also sends a small canal along the aquæductus vestibuli, which ends blindly at the surface of the petrous bone.

The **membranous semicircular canals** are about one-third the size of the osseous canals which lodge them; they open into the utricle. They have dilatations which correspond to the ampullæ, but the dilatation of the membranous canals is proportionally greater than that of the osseous ones, so that at these places they nearly fill the osseous cavities in which they lie. Here also the wall is much thickened, and on it branches of the vestibular nerve

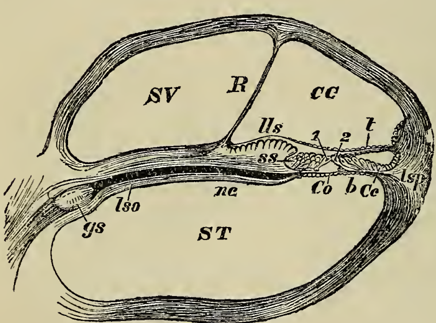


FIG. 343.—Section through one of the coils of the *Cochlea*. ST, scala tympani; SV, scala vestibuli; CC, canalis cochleæ or scala media; R, membrane of Reissner; *lls* to *lsp*, lamina spiralis membranacea; *lls*, limbus laminæ spiralis; *ss*, sulcus spiralis; *gs*, ganglion spirale seated on *nc*, the nervus cochlearis, indicated by the black line; *lso*, lamina spiralis ossea; *l*, membrana tectoria; *b*, membrana basilaris; C *o*, organ of Corti; *lsp*, ligamentum spirale; C *c*, cells of Claudius. 1. Inner rod of Corti. 2. Outer rod of Corti.

are thickly distributed. These canals contain endolymph, and have some few otoliths distributed over their epithelial lining.

The **membranous part of the cochlea** * not only completes the lamina spiralis, but also encloses a tube called the **canalis membranacea** or **scala media**, within which is a very complicated structure called the **organ of Corti.**

The description of the membranous cochlea, therefore, resolves itself into a description of this canal, its boundaries, and the parts contained in it.

Scala Media.—This canal is triangular in cross section, and is bounded externally by the osseous wall of the labyrinth, lined by its proper membrane. Internally it is bounded by a thin sheet called the **membrane of Reissner**, which separates it from the scala vestibuli. Its floor is formed by a membrane, which is stretched across from the lower edge of the osseous lamina spiralis to the cochlear wall, and is called the **membrana basilaris.**

* To understand the description of the membranous cochlea, it is necessary that the student should constantly refer to fig. 343.

The scala media accompanies the lamina spiralis throughout, and terminates superiorly in a cul-de-sac near the helicotrema; below, it also ends in a blind extremity, but from its inner side a small canal (*canalis reuniens*) passes to join the saccule, as already mentioned.

On the upper surface of the osseous lamina spiralis, near to its outer edge, there is a thick prominence, called *limbus lamina spiralis*, which is firmly connected with the periosteum of the lamina. Its surface is irregular, being marked by certain fungiform prominences; these are not all of the same length, the internal ones being short, while the external are long, and hang over towards the basilar membrane, so to form a groove beneath them, which is called the *sulcus spiralis.* Covering in the limbus, and stretching across from its outer edge to the outer wall of the scala, is an elastic membrane called *membrana tectoria* (membrane of Corti). It is nearly parallel with the basilar membrane, and thus divides the scala media into two parts, the inferior of which is the smallest, and contains the organ of Corti.

The **basilar membrane** is stretched across from the free edge of the osseous lamina to the outer wall of the spiral canal; it is on the same plane as the lamina itself, and is firmly attached at its outer extremity by means of a thick ligament (spiral ligament) to the cochlear wall.

The **membrane of Reissner** arises from the base of the limbus (or on its inner side), and extends across to the upper and outer part of the cochlear wall. It is directed somewhat obliquely, and separates the scala vestibuli from the scala media.

The **organ of Corti** consists of those structures which are contained between the membrana tectoria above and the basilar membrane below. Its central and most important part is formed of rod-like bodies, which are fixed firmly below to the basilar membrane, but above, their enlarged ends meet together like the beams of a roof, so as to enclose a triangular space. The inner rods overlap the outer, and the latter have a process bent back towards the outer side of the canal. On each side of these central bodies are others which appear to recline on the larger ones just described; they consist of an inner and an outer set.

The inner cells (*inner hair cells*) form a single layer, each cell terminating in fine, stiff, hair-like processes. Those on the outer side of the rods of Corti are more numerous and longer; they commonly form four or five rows, which incline towards the outer rod, and also terminate in branches of stiff hairs (*outer hair cells*). The hairs of the outer series project through ring-like processes which surmount the top of the cells, these processes presenting the appearance of a wire net, and forming what has been named the *reticular lamina.* On each side of the hair cells the epithelium becomes shorter and shorter, until at length it forms merely a cubical layer, which on the inner side partly fills up the sulcus spiralis, and on the outer side forms a covering for the basilar membrane.

VESSELS AND NERVES OF THE INTERNAL EAR.

Vessels.—The arteries of the labyrinth are derived from the internal auditory branch of the basilar artery, and from the stylo-mastoid branch of the posterior auricular. The auditory artery at the bottom of the meatus internus divides into cochlear and vestibular branches, which accompany the branches of the auditory nerve to the vestibule and cochlea.

The veins of the vestibule unite with those of the cochlea, and empty themselves into the superior petrosal sinus.

Nerves.—In order that the student may fully understand the distribution of the nerves of the internal ear, it is necessary, in the first place, that he should know something of the anatomy of the interior of the meatus auditorius internus.

The **meatus** pursues a course directly outwards; it is about one-third of an inch in length, and terminates in two deep depressions, separated by a sharp horizontal ridge. The *superior depression*, the smaller of the two, is divided by a vertical ridge into an anterior portion, forming the commencement of the aquæductus Fallopii, and a posterior portion, which corresponds with the upper part of the inner wall of the vestibule, and is pierced by numerous small foramina. The *inferior depression* presents posteriorly an oval pit, pierced by numerous foramina, opening into the vestibule; near its anterior extremity, it is marked by a spiral groove pierced by minute openings for the passage of filaments of the cochlear nerve; this is called *tractus spiralis foraminulentus.* In the centre of the small piece of bone which this groove isolates, is one foramen larger than the rest, which leads into the central canal of the modiolus, *tubulus centralis modioli.* Upon the posterior wall of the lower depression, and opposite to the spiral groove, is a longitudinal groove leading to a foramen, for the transmission of a considerable branch of the vestibular nerve.

The auditory and facial nerves enter the meatus internus together, accompanied by the auditory branch of the basilar artery. At the bottom of the meatus the facial enters the aqueduct of Fallopius, and is conducted along it to the stylo-mastoid foramen, as already described.

The **auditory** nerve divides into two branches at the bottom of the meatus, a vestibular nerve and a cochlear nerve, the latter lying anterior to the former, and a little below the facial nerve.

The **vestibular** nerve separates into three branches, superior, middle, and inferior. The *superior* vestibular branch gives off a number of filaments, which pass through the foramina in the posterior part of the superior depression; they enter the vestibule beside the crista vestibuli, and are distributed to the utricle, and the ampulla of the superior and external semicircular canals. The *middle* vestibular branch sends off numerous filaments, which pass through the foramina in the lower depression, enter the vestibule through the fovea hemispherica, and are distributed to the saccule.

The *inferior* and smallest branch passes along the groove and through the foramen at the back part of the meatus; it is distributed to the ampulla of the posterior canal. The filaments which pass to the canals bifurcate at their extremities, and are applied against the flattened side of each membranous ampulla; they then pass into the membranous wall, and into the partial septum, which has been already described as projecting into the ampulla.

The **cochlear** nerve divides into numerous filaments, which enter the foramina of the tractus spiralis in the base of the cochlea, pass upwards in the canals of the modiolus, and, bending outwards at right angles, pass between the two layers of the osseous lamina spiralis. Here the nerve filaments form a network, in the midst of which numerous small ganglia have been observed. From this plexus branches are given off externally, which perforate the bottom of the sulcus spiralis, and, it is supposed, terminate by becoming attached to the rods of Corti, and the cells which adjoin them on each side. The central portion of the cochlear nerve passes through the tubulus centralis modioli, and supplies the apicial portion of the lamina spiralis, and the adjoining structures.

ORGAN OF TASTE.

The **tongue** is composed of muscular fibres, which are distributed in layers arranged in various directions: thus, some are disposed *longitudinally* (lingualis superficialis); others *transversely* (lingualis transversus); others, again, *obliquely* and *vertically*. The arrangement of the different bundles forming the intrinsic muscles of the tongue has been described on a previous page (p. 251). Between the muscular fibres is a considerable quantity of adipose substance, and in the middle of the organ a vertical septum of fibrous tissue.

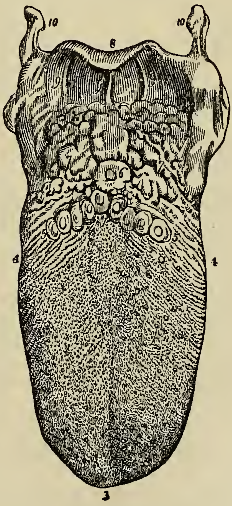


FIG. 344.—The tongue with its papillæ. 1. The raphé, which sometimes bifurcates on the dorsum of the tongue, as in the figure. 2, 2. Lobes of the tongue; the rounded eminences on this part, and near its tip, are the fungiform papillæ. The smaller papillæ, among which the former are dispersed, are the filiform papillæ. 3. Tip of the tongue. 4, 4. Its sides. 5, 5. The A-shaped row of circumvallate papillæ. 6. Foramen cæcum. 7. Mucous glands of the root of the tongue. 8. Epiglottis. 9, 9. Glosso-epiglottidean folds. 10, 10. Greater cornua of the os hyoides.

The tongue is *connected*, posteriorly, with the os hyoides by muscular attachment; and to the epiglottis by mucous membrane, which forms the three glosso-epiglottic folds

called *fræna epiglottidis.* At either side it is held in connection with the lower jaw by mucous membrane; and in front, a fold of that membrane, which is named *frænum linguæ*, is formed beneath its under surface. It is also connected with the soft palate by means of the anterior pillars of the fauces.

The upper surface of the tongue is covered by a dense layer of mucous membrane, studded over in its anterior three-fourths by prominent papillæ, and presenting an irregular surface in its posterior fourth due to the projection of thickly crowded mucous glands. A *raphé* marks the middle line of the organ, and divides it into symmetrical halves.

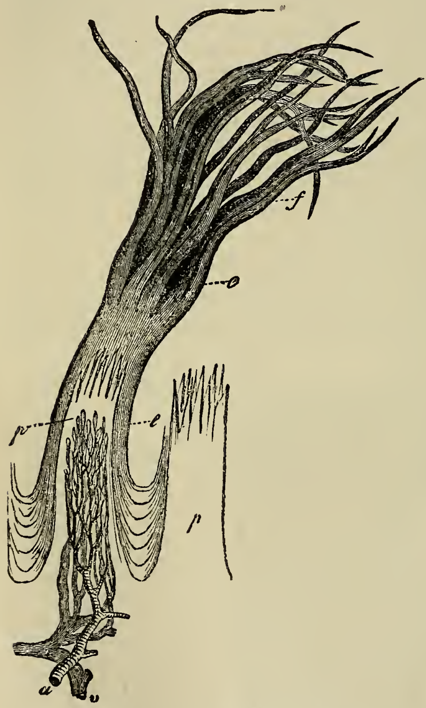


FIG. 345.—Filiform papillæ of tongue. *a.* Artery. *v.* Vein. *p, p.* Primary papillæ. *e, e.* Epithelial covering ending in the tufted processes, *f.*

The **papillæ** of the tongue are the—

Circumvallate papillæ,
Filiform or conical papillæ,
Fungiform papillæ.

The **circumvallate papillæ** (p. lenticulares) are of large size, and from fifteen to twenty in number. They are situated on the dorsum of the tongue, near its root, and form a row at each side, which meets its fellow at the middle line, like the two branches of the letter A. Each papilla resembles a cone, attached by its apex to the bottom of a cup-shaped depression; hence they are also named papillæ **calyciformes.** This cup-shaped cavity forms a kind of fossa around the papilla, whence their name **circumvallatæ.** At the meeting of the two rows of these papillæ upon the middle of the root of the tongue, is a deep depression called **foramen cæcum,** into which several mucous follicles open.

The **filiform papillæ** cover the whole surface of the tongue in front of the circumvallate papillæ, but are most abundant towards its anterior part. They are conical at their base, and have projecting

from their apices filiform processes, which are found to be products of the epithelium. They are arranged in rows, which at the back part of the tongue are nearly parallel with the circumvallate papillæ, but get more longitudinal in their direction as we proceed forwards, so that at the tip of the tongue they get to be nearly parallel with the raphé.

The **fungiform papillæ** are irregularly dispersed over the dorsum of the tongue, and are easily recognised among the other papillæ by their rounded heads, larger size, and red colour. A number of these papillæ will generally be observed at the tip of the tongue.

All these papillæ have minute secondary papillæ projecting from their surfaces, and these are coated with a very dense epithelial layer, which is generally flat over the circumvallate and fungiform papillæ, but in the others forms hair-like processes, which vary greatly in their size and shape.

The circumvallate and fungiform papillæ appear alone to possess the special sense of taste, the filiform being much too dense at their apices for the apprehension of delicate sensation, and hitherto no nerve filaments have been traced into the secondary papillæ which surmount them. The filiform, however, are probably endowed with common sensation, and it is manifest that they perform important service in assisting mastication.

Behind the papillæ circumvallatæ, at the root of the tongue, are a number of mucous glands (*lingual*), which open on the surface. There is also a small cluster beneath the tip of the tongue.

Taste-buds.—These are believed to be the special organs of taste; they are found on the sides of the circumvallate papillæ embedded in the substance of the mucous membrane, one end being in contact with the corium, the other opening by minute pores on to the surface. They consist of numerous aggregated epithelial cells, the central ones being spindle-shaped, the peripheral ones flattened, with tapering ends. The free end of each cell is sharp and pointed, and projects through the pore; the deep extremity is branched and connected with a plexus of nerve fibres.

Fig. 346.—Taste-buds from the lateral gustatory organ of a rabbit.

Vessels and Nerves.—The tongue is abundantly supplied with blood by the lingual arteries.

The **nerves** are three in number, and of large size; the *gustatory* or *lingual* branch of the inferior maxillary is distributed to the

papillæ and mucous membrane generally of the fore part and sides of the tongue; it is the nerve of common sensation to those parts. With it are distributed filaments of the chorda tympani; these seem to go chiefly to the papillæ, and experiments tend to show that the sense of taste in the front and sides of the tongue is due to these, and not to the gustatory filaments, as was formerly supposed.

The **glosso-pharyngeal** nerve is distributed to the back part of the tongue, and more especially to the circumvallate papillæ; it endows those parts with the sense of taste. The **hypoglossal** nerve is the motor nerve distributed to the muscles of the tongue.

The terminal filaments of the sensory nerves are supposed in some cases to become attached to the inner ends of the epithelial cells, especially those forming the taste-buds; the connection bearing a close resemblance to that observed in the retina, the cochlea, and the nasal mucous membrane.

The **mucous membrane** which invests the tongue is continuous with the derma along the margin of the lips. On either side of the frænum linguæ it may be traced through the sublingual ducts into the sublingual glands, and along Wharton's ducts into the submaxillary glands; from the sides of the cheeks it passes through the opening of Stenson's ducts to the parotid glands; in the fauces, it forms the assemblage of mucous crypts called tonsils, and may thence be traced downwards into the larynx and pharynx, where it is continuous with the general gastro-pulmonary mucous membrane.

Beneath the mucous membrane of the mouth are a number of small *glands*, which pour their secretion upon the surface. A considerable number of these bodies are situated within the lips, in the palate, and in the floor of the mouth. They are named according to their position—*labial glands*, *palatal glands*, and *buccal glands*.

ORGAN OF TOUCH.

The **skin** is the exterior investment of the body, which it serves to cover and protect. It is continuous at the apertures of the internal cavities with the lining membrane of those cavities, the internal skin or mucous membrane, and is composed essentially of two layers, *derma* and *epidermis*.

The **DERMA**, **cutis vera** or **corium**, is the deep layer of the skin; it is composed of areolar tissue, muscular tissue, and fat, together with numerous blood-vessels, lymphatics, and nerves, which ramify through it. For convenience of description it is divided into a **reticular** and **papillary** layer, but it must be remembered that these are nowhere separable the one from the other.

The **reticular** or deep layer of the derma presents some variety in thickness in different parts of the body. Thus in the more exposed regions, as the back, the outer sides of the limbs, the palms, and the soles, it is remarkable for its thickness; while on protected parts

it is comparatively thin, and on the eyelids, penis, and scrotum is peculiarly delicate. It is connected by its under surface with the common superficial fascia of the body. It is composed chiefly of white fibrous tissue collected into bundles, which are small and closely packed in the upper strata, large and coarse in the deeper strata; in the latter they form large areolæ, which contain adipose tissue, and in the midst of the fibrous bundles the hair-bulbs and the sudoriferous glands are embedded. The superficial strata contain much yellow elastic tissue, the quantity of which varies in different parts of the body, being much increased in the neighbourhood of joints. The deep strata contain unstriped muscular fibres, which are either gathered into bundles or dispersed among the fibrous tissue. In some parts the muscular tissue is so thick as to form a distinct layer, as in the "tunica dartos" of the scrotum, in the nipple and its areola, the penis and the perineum. There are also distinct bands of muscle connected with the hair follicles; these will be described in speaking of the hairs.

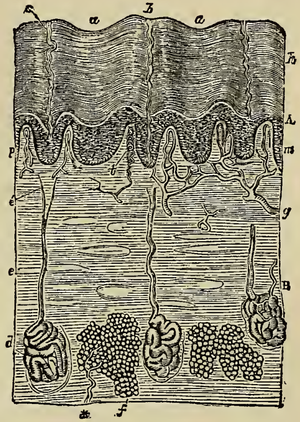


Fig. 347.—Vertical section of skin of finger. A. Epidermis, the surface of which shows hollow depressions, *a*, *a*, between the papillary eminences, *b*, and the openings of the perspiratory ducts, *s*; at *m* is seen the deeper layer of the epidermis, or rete mucosum. B. Cutis vera, in which are embedded the perspiratory glands, *d*, with their ducts, *e*, and also aggregations of fat vesicles, *f*; at *g* is seen an arterial twig supplying the vascular papillæ, *p*; and at *t* one of the tactile papillæ with its nerve.

Throughout the whole of the reticular layer *connective-tissue corpuscles* are found; they generally anastomose so as to form a network.

The **papillary** or superficial layer of the derma is raised in the form of conical prominences or papillæ. On the general surface of the body the papillæ are short and exceedingly minute; but in other situations, as the palmar surface of the hands and fingers, and the plantar surface of the feet and toes, they are long and of large size. They also differ in arrangement; for, on the general surface, they are distributed at unequal distances and without order; whereas, on the palms and soles, and on the corresponding surfaces of the fingers and toes, they are collected into little square clumps, containing from ten to twenty papillæ, and these little clumps are disposed in parallel rows. It is this arrangement in rows that gives rise to the characteristic parallel ridges and furrows which are met with on the hands and feet. The papillæ in these little square clumps are for the most part uniform in size and length, but every here and there one papilla may be observed which is longer than

the rest. The largest papillæ of the derma are those which produce the nail; in the dermal follicle of the nail they are long and filiform, while beneath its concave surface they form longitudinal and parallel plications which extend for nearly the entire length of that organ. In structure the papilla is composed of homogeneous,

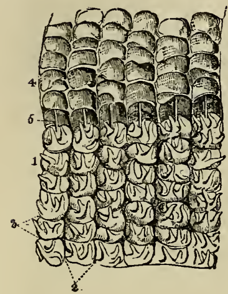


FIG. 348.—Portion of skin from the palm of the hand. 1. Papillary layer. 2. Longitudinal furrows, marking the arrangement of the papillæ into ridges. 3. Transverse furrows dividing the ridges into small quadrangular clumps. In the figure a few only of the papillæ are shown. 4. Rete mucosum raised from the papillary layer; its under surface presents an exact impression of the papillary layer. 5, 5. Perspiratory ducts drawn out straight by the separation of the rete mucosum from the papillary layer; the point at which each perspiratory duct issues from the papillary layer, and pierces the rete mucosum, is the middle of the transverse furrow between the quadrangular clumps.

nucleated, and fibrillated areolar tissue, with a few transverse elastic fibres. The papillæ are separated from the epidermis by an apparently homogeneous **basement membrane**, which becomes evident as a transparent line, when the tissue is treated with a solution of chloride of gold. The papillæ are divisible into *vascular* and *nervous*, the former predominating; some of the nervous papillæ are occupied by a peculiar form of nerve termination called the **tactile corpuscle** of Meissner or Wagner.

The **EPIDERMIS** or cuticle (scarfskin) covers the superficial surface of the derma, which it serves to envelop and defend. That surface of the epidermis which is exposed to the influence of the atmosphere and exterior sources of injury, is hard and horny in texture, while that which lies in contact with the papillary layer is soft and cellular. Hence the epidermis, like the derma, is divisible into two layers, external and internal, the latter being termed the **rete mucosum.** Moreover, the epidermis is laminated in structure, and the laminæ present a progressively increasing tenuity and density as they advance from the inner to the outer surface. This difference of density is dependent on the mode of growth of the epidermis, for as the external surface is constantly subjected to destruction from attrition and chemical action, so the membrane is continually reproduced on its internal surface; new layers being successively formed on the derma to take the place of the old.

Immediately in contact with the basement membrane covering the papillæ is a layer of columnar cells, and it is believed that these are the active agents in the selection of nourishment from the corium for the epidermis, and in the production of the new cells of the *rete mucosum.* These cells, by drawing nourishment from the corium, increase rapidly in size, more especially in length; the

upper part then becomes separated from the rest to form a new cell, while the lower part, remaining still attached to the basement membrane, again elongates by the imbibition of new material; again it divides, and so *ad infinitum.* The cells thus formed become larger by drawing nourishment from the corium, and it is probable that they also divide to form other cells. As this process goes on, the newest formed cells push the older ones away from the corium, and as the latter ascend towards the surface of the skin they undergo certain changes. In consequence of the pressure which they sustain they become flattened; as they get beyond the range of nutrition they become altered in consistence; and, finally, they become subject to evaporation. Thus it happens that the cell which is at first spherical becomes elliptical, then becomes still more flattened, and at length desiccates into a thin membranous scale, in which the nucleus is scarcely apparent; in this last form it is thrown off.

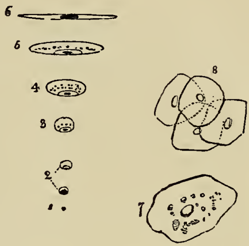


FIG. 349.—Diagram illustrative of the development of the epidermis and of epithelia in general. 1. A new cell. 2. The cell seen to be increased in size. 3. The spheroidal cell. 4. The oval cell. 5. The elliptical cell. 6. The flattened cell; which, by contact of its walls, is speedily converted into a scale. 7. A nucleated scale as seen on its flat surface. 8. A cluster of such scales.

The cells situated immediately above the columnar layer are marked on their surface by irregular ridges and furrows, and sometimes by small spines; the ridges do not fit into the furrows, but the result of their presence is that minute channels are left between the cells, which probably serve for the passage of nutrient fluid. Wander cells are often observed among the cells of the rete mucosum.

The under surface of the epidermis is accurately modelled on the papillary layer of the derma, each papilla having its appropriate sheath in the newly-formed epidermis or rete mucosum, and each irregularity of surface of the former having its representative in the soft tissue of the latter. On the external surface, this character is lost; the minute elevations corresponding with the papillæ are, as it were, polished down, and the surface is rendered smooth and uniform. The palmar and plantar surface of the hands and feet are, however, an exception to this rule; for here in consequence of the large size of the papillæ and their peculiar arrangement in rows, ridges corresponding with the papillæ are strongly marked on the superficial surface of the epidermis. The epidermis is remarkable for its thickness in situations where the papillæ are large, as in the palms and soles. In other situations, it assumes a character which is also due to the nature of the surface of the derma; namely, that of being marked by a network of linear furrows, which trace out the surface into small polygonal and lozenge-shaped areæ. These

lines correspond with the folds of the derma produced by its movements, and are most numerous where those movements are greatest, as in the flexures and on the convexities of joints.

The dark colour of the skin among the natives of the South is due to the presence of pigment granules in the cells of the rete mucosum. As the cells desiccate, the colour of the granules is lost, so that the cells of the superficial layers are very little darker in the skin of the negro than in that of the white man.

The **pores** of the epidermis are the openings of the perspiratory ducts, hair follicles, and sebaceous glands.

Vessels and Nerves.—The **arteries** of the derma, which enter its structure through the areolæ of the under surface of the corium, divide into innumerable intermediate vessels, which form a rich capillary plexus in the superficial strata of the skin and in its papillary layer. In the papillæ of some parts of the derma, as in the longitudinal plications beneath the nail, the capillary vessels form simple loops, but in other papillæ they are convoluted to a greater or less degree in proportion to the size and importance of the papillæ. Capillary plexuses are also found around the groups of fat vesicles, the sweat glands, and hair follicles. The **lymphatic** vessels probably form, in the superficial strata of the derma, a plexus, the meshes of which are interwoven with those of the capillary and nervous plexus. In some parts of the palm of the hand and sole of the foot, lymphatics pass into the papillæ, but do not reach their summit.

The **nerves** of the derma, after entering the areolæ of the deeper part of the corium, divide into minute fasciculi, which form a terminal plexus in the upper strata of the corium. From this plexus the primitive fibres pass off to their distribution as loops, in the papillæ. In the less sensitive parts of the skin the loops are simple and more or less acute in their bend, in conformity with the figure

FIG. 350.—Three groups of tactile papillæ from the skin of the index finger, in vertical section. Some are supplied with vascular loops, some with tactile corpuscles.

of the papillæ. In the sensitive parts, and especially in the tactile papillæ of the pulps of the fingers, the nerves terminate in special sense organs, namely end-bulbs, Pacinian bodies, and tactile corpuscles; the two former have already been described (p. 33). The **tactile corpuscles** (discovered by Wagner and Meissner) are oval bodies about $\frac{1}{300}$ inch long, having externally a capsule of connective tissue with oval nuclei, some of the fibres being wound round

horizontally. The central part is soft, transparent, and homogeneous, and receives the termination of the nerve fibre which apparently breaks up in it into a number of minute pale fibrils.

APPENDAGES OF THE SKIN.

The appendages of the skin are the nails, hairs, sebaceous glands, and perspiratory glands and ducts.

The **NAILS** are horny appendages of the skin, identical in formation with the epidermis, of which they are a part. A nail is convex on its external surface, concave within, and implanted by means of a thin margin or root in a fold of the derma, which is nearly two lines in depth, and acts the part of a follicle to the nail. At the bottom of the groove of the follicle are a number of filiform papillæ, which produce the margin of the root, and, by a successive formation of new cells, push the nail onwards in its growth. The concave surface of the nail is in contact with the derma, and the latter forms the **matrix** of the nail, and is covered by papillæ, which perform the double office of retaining the nail in its place, and giving it increased thickness by the addition of newly-formed cells to its under surface. It is this constant change occurring in the under surface of the nail, co-operating with the continual formation taking place along the margin of the root, which ensures the growth of the nail in the proper direction. The nail derives a peculiarity of appearance from the disposition and form of the papillæ of the matrix. Thus, beneath the root, and for a short distance onwards towards its middle, the derma is covered by papillæ which are more minute, and consequently less vascular than the papillæ somewhat farther on. This patch of papillæ is bounded by a semilunar line, and that part of the nail covering it being lighter in colour than the rest, has been termed *lunula.* Beyond the lunula the papillæ are raised into longitudinal plaits, which are exceedingly vascular, and give a deeper tint of redness to the nail. These plait-like papillæ of the derma are well calculated by their form to offer an extensive surface both for the adhesion and formation of the nail. The granules and cells are developed on every part of their surface, both in the grooves between the plaits and on their sides, and a horny lamina is formed between each pair of plaits. When the under surface of a nail is examined, these longitudinal laminæ, corresponding with the longitudinal papillæ of the ungual portion of the derma, are distinctly apparent, and if the nail be forcibly detached, the laminæ may be seen in the act of parting from the grooves of the papillæ. It is this structure that gives rise to the ribbed appearance of the nail. The papillary substance of the derma which produces the nail is continuous around the circumference of the attached part of that organ with the derma of the surrounding skin, and the horny structure of the nail is consequently continuous with that of the epidermis.

HAIRS are horny appendages of the skin, produced by the involution and subsequent evolution of the epidermis; the involution

constituting the follicle in which the hair is enclosed, and the evolution the shaft of the hair. Hairs vary much in size and length in different parts of the body; in some they are so short as not to appear beyond the follicle; in others, they grow to a great length, as on the scalp; while along the margins of the eyelids, and in the whiskers and beard, they are remarkable for their thickness. Hairs are generally more or less flattened in form, and when the extremity of a transverse section is examined, it is found to possess an elliptical or reniform outline. This examination also demonstrates that the centre of the hair is porous and loose in texture, while its periphery is dense; thus affording ground for its division into a *cortical* and a *medullary* portion. The free extremity of a hair is generally pointed, and sometimes split into two or three filaments. Its attached extremity is implanted deeply in the integument, extending through the derma into the subcutaneous areolar tissue, where it is surrounded by adipose cells. The central extremity of a hair is larger than its shaft, and is called the root or bulb. It is rounded or conical in shape.

The outer surface of the hair is covered by a layer of flattened cells, which overlap each other at the edges like the tiles of a house. The bulk of the shaft consists of cells which have become flattened, elongated, and welded together, the union being often so intimate that no indication of the individual elements from which it is formed can be made out, except by the aid of chemical reagents. Very small elongated nuclei may be demonstrated among the fibres, and occasional dark streaks, some of which are due to deposits of pigment, and others to air spaces. The bulb of the hair has projecting into it a small process or papilla from the derma; it contains blood-vessels and nerves, and furnishes nutriment to the cells of the bulb, by the multiplication of which the hair increases in size.

The hair is contained in a depression passing deeply into the reticular layer of the corium, and called the **hair follicle**. It is wide in its deepest part where it contains the bulb, gets narrower at the entrance of the ducts of the sebaceous glands, and again widens as it nears the surface. Its wall consists of two distinct layers, called respectively the **external** and **internal sheath of the follicle**, the former being continuous with the corium, and the latter with the epidermis. Between these layers and the hair itself a delicate structure is observed, called the **root sheath**; it is also described as composed of an outer and an inner layer. The inner layer (*Huxley's sheath*) consists of flat

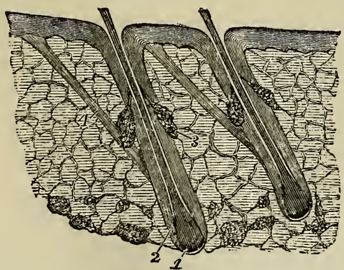


FIG. 351.—The hairs and their connections. 1. Hair bulb. 2. Inner sheath of the follicle. 3. Sebaceous gland. 4. Erector pili.

cells which answer to the horny layer of the epidermis; the outer is composed of soft cells like those of the *rete mucosum*, some of them containing pigment (*layer of Henle*).

Connected with the hair follicles there are some fine bands of unstriped muscular fibre. These arise from the superficial part of the corium, and are inserted into the outside of the lower part of the follicle, below the sebaceous gland. They are placed on the side towards which the hair slopes, and by their contraction *erect* the hair; hence they have received the name of **erectores pili.**

The colour of the hair, like that of the epidermis, is due to pigment deposited in the central cells.

The **SEBACEOUS GLANDS** are embedded in the substance of the derma, and present every degree of complexity, from the simplest follicle to the compound lobulated gland. In some situations their excretory ducts open independently on the surface of the epidermis; while in others, they terminate in the follicles of the hairs. The sebaceous glands associated with the hairs are racemose and lobulated, consisting of glandular vesicles which open by short pedunculated tubuli into a common excretory duct, and the latter, after a short course, into the hair follicle. In the scalp there are two of the glands to each hair follicle. On the nose and face the glands are of large size, and constantly associated with small hair follicles. In the meatus auditorius the *ceruminous* glands are also large; in the eyelids the cilia are supplied like other hairs with sebaceous glands, but the Meibomian glands may also be regarded as belonging to this class. The excretory ducts of sebaceous glands offer some diversity in different parts of the body; in many situations they are short and straight, in others, as in the palms of the hands and soles of the feet, where the epidermis is thick, they assume a spiral course. The sebaceous ducts are lined by an inversion of the epidermis, which forms a thick and funnel-shaped cone at its commencement, but soon becomes uniform and soft. Sebaceous glands are met with in all parts of the body, but are most abundant in the skin of the face, and in those situations which are naturally exposed to the influence of friction.

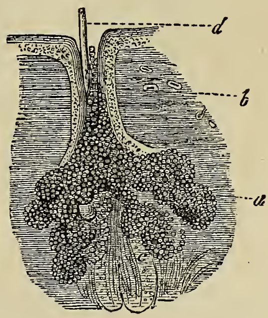


FIG. 352.—A sebaceous gland. *a.* The gland vesicles. *b.* Excretory duct. *c.* The follicle of a downy hair. *d.* Shaft of the latter.

The sebaceous substance when it collects in inordinate quantities within the excretory ducts becomes the habitat of a remarkable parasitic animal, the *steatozoon folliculorum.*

The **SUDORIPAROUS** or **SWEAT GLANDS** are situated deeply in the corium and also in the subcutaneous areolar tissue, where they are surrounded by adipose cells. They are small round

or oblong bodies, composed of one or more convoluted tubuli, which open into a common efferent duct. The latter ascends from the gland through the derma and epidermis, and terminates on the surface by a funnel-shaped and oblique aperture or pore. Each gland mass is surrounded by a fine plexus of capillary vessels. The efferent duct presents some variety in its course upwards; within the derma it is straight, or curved and serpentine, and if the epidermis be thin, proceeds more or less directly to the excreting pore. Sometimes it is spirally curved within the derma, and having passed the latter, is regularly and beautifully spiral in its passage through the epidermis, the last forming an oblique and valvular opening on the surface. The spiral course of the duct is especially remarkable in the thick epidermis of the palm of the hand and sole of the foot. On those parts of the skin where the papillæ are irregularly distributed, the efferent ducts of the sudoriparous glands open on the surface also irregularly, while on the palmar and plantar surfaces of the hands and feet, the pores are situated at regular distances along the ridges, at points corresponding with the intervals of the small, square-shaped clumps of papillæ. Indeed, the apertures of the pores, seen on the surface of the epidermal ridges, give rise to the appearance of small transverse furrows, which intersect the ridges from point to point.

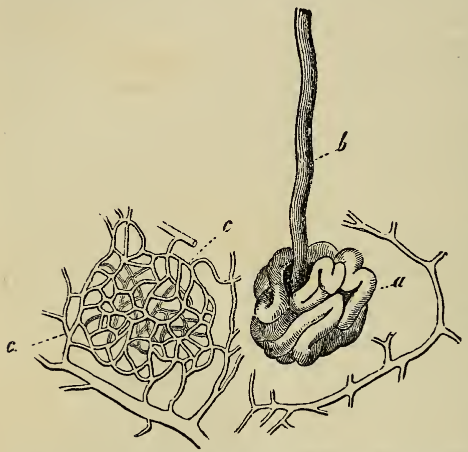


Fig. 353.—Sudoriparous gland and its capillary plexus. *a*. Convoluted portion. *b*. Excretory duct. *c, c*. Basket-like capillary plexus from around a convolution, with arterial twigs.

The efferent duct and tubuli of the sudoriparous gland are lined by epithelium consisting of one or more strata of cells; many of the cells are pigmented. In some of the larger glands a longitudinal layer of unstriped muscular fibre is found in the outer coat, in addition to the connective tissue which forms this coat in the rest of the glands. A good view of the sudoriparous ducts is obtained by gently separating the epidermis of a portion of decomposing skin; or they may be better seen by scalding a piece of skin, and then withdrawing the epidermis from the derma. In both cases it is the lining sheath of epidermis, in other words, the epithelium, which is drawn out from the duct.

PART VII.

SPLANCHNOLOGY.

That part of the science of anatomy which treats of the viscera is named splanchnology, from the Greek words σπλάγχνον, viscus, and λόγος. The viscera of the human body are situated in the three great internal cavities: cranio-spinal, thorax, and abdomen. The viscera of the cranio-spinal cavity, namely, the brain and spinal cord, with the principal organs of sense, have been already described, in conjunction with the nervous system. The viscera of the chest are: the central organ of circulation, the heart; the organs of respiration, the lungs; and the thymus gland. The abdominal viscera admit of a subdivision into those which properly belong to that cavity—viz., the alimentary canal, liver, pancreas, spleen, kidneys, and supra-renal capsules; and those of the pelvis: the bladder and internal organs of generation.

THORAX.

The thorax is the conical cavity situated at the upper part of the trunk of the body; it is narrow above and broad below, and is bounded in *front*, by the sternum, six superior costal cartilages, ribs, and intercostal muscles; *laterally*, by the ribs and intercostal muscles; and, *behind*, by the ribs, intercostal muscles, and vertebral column, as low down as the upper border of the last rib and first lumbar vertebra; *superiorly*, by the first rib at each side, the upper part of the sternum in front and the first dorsal vertebra behind; and, *inferiorly*, by the diaphragm. The superior opening of the thorax gives passage to the following parts, namely, the sterno-hyoid, sterno-thyroid, and longus colli muscles; the remains of the thymus gland; the trachea, œsophagus, and thoracic duct; left carotid, left subclavian, innominate, superior intercostal, and internal mammary arteries; the right and left innominate and inferior thyroid veins; the pneumogastric, cardiac, left recurrent laryngeal, phrenic, and sympathetic nerves; the anterior division of the first dorsal nerve;

and the upper part of the lungs and pleuræ. The cavity of the thorax is much deeper on the posterior than on the anterior wall, in consequence of the obliquity of the diaphragm, and contains the heart enclosed in its pericardium, with the great vessels; the lungs, with their serous coverings, the pleuræ; the œsophagus; some important nerves; and, in the fœtus, the thymus gland.

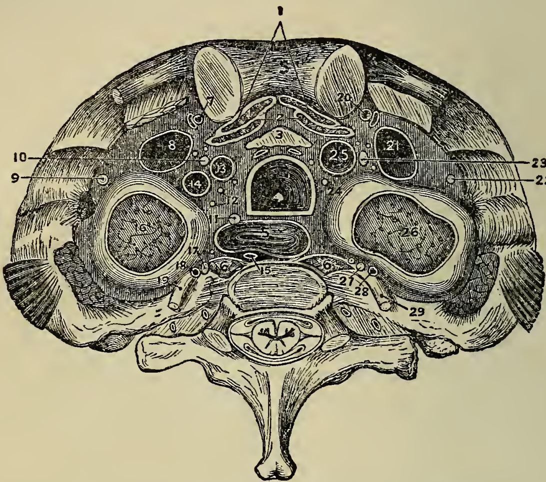


FIG. 354.—Upper opening of the thorax. *Median line.* 1. Sterno-hyoid. 2. Sterno-thyroid. 3. Remains of thymus gland. 4. Trachea. 5. Œsophagus. 6. Longus colli muscles. *Left side.* 7. Internal mammary artery. 8. Innominate vein. 9. Phrenic nerve. 10. Pneumogastric nerve. 11. Recurrent laryngeal nerve. 12. Cardiac nerves. 13. Left carotid artery. 14. Left subclavian artery. 15. Thoracic duct. 16. Apex of lung and pleura. 17. Sympathetic nerve. 18. Superior intercostal artery. 19. First dorsal nerve. *Right side.* 20. Internal mammary artery. 21. Innominate vein. 22. Phrenic nerve. 23. Pneumogastric nerve. 24. Cardiac nerves. 25. Innominate artery. 26. Apex of lung and pleura. 27. Sympathetic nerve. 28. Superior intercostal artery. 29. First dorsal nerve.

PERICARDIUM.

The central organ of circulation, the heart, is situated between the two layers of pleura which constitute the mediastinum, and is enclosed in a proper membrane, the pericardium.

The pericardium is a fibro-serous membrane, its serous layer being reflected from the serous membrane of the viscus which it encloses. In shape it is like a truncated cone, the base being downward, the truncated apex upward, surrounding the aorta. It consists of two layers, external, fibrous; and internal, serous. The *fibrous* layer is attached above to the great vessels proceeding from the heart, on which it is continuous with the deep cervical fascia;

and below, to the tendinous portion of the diaphragm. Where it encloses the great vessels it is prolonged on them for some distance in a tubular form, and at length becomes lost in their outer coat. The vessels which are partly covered by it are eight in number, namely, the aorta, superior vena cava, four pulmonary veins, and right and left divisions of the pulmonary artery. The *serous* membrane invests the heart with the commencement of its great vessels as high as the arch of the aorta, and is then reflected upon the internal surface of the fibrous layer.

In intimate structure the fibrous layer is composed of strong interlacing fibres, the serous layer consisting of a thin stratum of elastic tissue disposed in a network, adherent by one surface to the fibrous layer, and smooth on the free surface, where it gives support to a single or double lamina or tesselated epithelium. The bag of the pericardium has few vessels and nerves, the latter being derived from the phrenic and recurrent branch of the right pneumogastric.

HEART.

The heart is placed obliquely in the chest, the *base* being directed upwards and backwards towards the right shoulder, and corresponding to the intervals between the fourth and eighth dorsal vertebræ; the *apex* forwards and to the left, pointing to the space between the fifth and sixth rib, at about two and a half inches from the sternum. Its *under side* is flattened, and rests on the tendinous portion of the diaphragm; its *upper side* is rounded and convex, and formed principally by the right ventricle, and partly by the left; the *lower* or *right* border, formed chiefly by the right auricle, is thin and longer than the left border; the latter is formed by the left ventricle, and is thick and rounded. Surmounting the ventricles are the corresponding auricles, whose auricular appendages are directed forwards, and slightly overlap the root of the pulmonary artery. The pulmonary artery is the large anterior vessel at the root of the heart; it crosses obliquely the commencement of the aorta. The heart consists of two auricles and two ventricles, which are respectively named, from their position, right and left. The right is the venous side of the heart; it receives into its auricle the venous blood from every part of the body, by the superior and inferior cava and coronary sinus. From the auricle the blood passes into the ventricle, and from the ventricle through the pulmonary artery to the capillaries of the lungs. From these it is returned as arterial blood to the left auricle; from the left auricle it passes into the left ventricle, and from the left ventricle is carried through the aorta, to be distributed to every part of the body and again returned to the heart by the veins. This constitutes the course of the adult circulation.

The heart is best studied *in situ*. If, however, it be removed from the body, it should be placed in the position indicated by the above description of its situation. A transverse incision should

then be made along the ventricular margin of the right auricle, from the appendix to its right border, and crossed by a perpendicular incision carried from the side of the superior to the inferior cava. The blood must then be removed.

The **RIGHT AURICLE** is larger than the left, and consists of a principal cavity and an auricular appendix; the former is the part into which the great veins empty their blood, and it hence receives the name of **sinus venosus** or **atrium.** The interior of the sinus

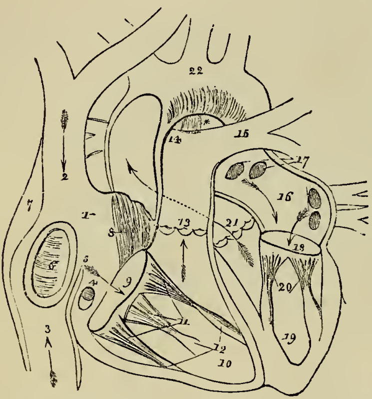


FIG. 355.—Anatomy of the heart. 1. Right auricle. 2. Entrance of the superior vena cava. 3. Entrance of the inferior cava. 4. Opening of the coronary sinus, half closed by the coronary valve. 5. Eustachian valve. 6. Fossa ovalis, surrounded by the annulus ovalis. 7. Tubercle of Lower. 8. Musculi pectinati of the appendix auriculæ. 9. Auriculo-ventricular opening. 10. Cavity of the right ventricle. 11. Tricuspid valve, attached by the chordæ tendineæ to the carneæ columnæ (12). 13. Pulmonary artery, guarded at its commencement by three semilunar valves. 14. Right pulmonary artery, passing beneath the arch and behind the ascending aorta. 15. Left pulmonary artery, crossing in front of the descending aorta. * Remains of the ductus arteriosus, acting as a ligament between the pulmonary artery and arch of the aorta. The arrows mark the course of the venous blood through the right side of the heart. Entering the auricle by the superior and inferior cavæ, it passes through the auriculo-ventricular opening into the ventricle, and thence through the pulmonary artery to the lungs. 16. Left auricle. 17. Openings of the four pulmonary veins. 18. Auriculo-ventricular opening. 19. Left ventricle. 20. Mitral valve, attached by its chordæ tendineæ to two large columnæ carneæ, which project from the walls of the ventricle. 21. Commencement and course of the ascending aorta behind the pulmonary artery, marked by an arrow. The entrance of the vessel is guarded by three semilunar valves. 22. Arch of the aorta. The comparative thickness of the two ventricles is shown in the diagram. The course of the pure blood through the left side of the heart is marked by arrows. The blood is brought from the lungs by the four pulmonary veins into the left auricle, and passes through the auriculo-ventricular opening into the left ventricle, whence it is conveyed by the aorta to every part of the body.

presents for examination five openings, two valves, two relics of fœtal structure, and two peculiarities in the proper structure of the auricle. To facilitate remembrance they may be thus arranged :—

Openings	Superior cava, Inferior cava, Coronary sinus, Foramina Thebesii, Auriculo-ventricular.	Relics of fœtal structure	Annulus ovalis, Fossa ovalis.
Valves	Eustachian valve, Coronary valve.	Structure of the auricle	Tubercle of Lower, Musculi pectinati.

The **superior vena cava** returns the blood from the upper half of the body, and opens into the upper and back part of the auricle.

The **inferior vena cava** returns the blood from the lower half of the body, and opens through the lower and posterior wall, close to the partition between the auricles (septum auricularum). The direction of these two vessels is such, that a stream forced through the superior cava would rush towards the auriculo-ventricular opening. In like manner, a jet issuing from the inferior cava would dash its stream against the septum auricularum ; this is the proper direction of the two currents during fœtal life.

The **coronary sinus** returns the venous blood from the substance of the heart ; it opens into the auricle between the inferior cava and auriculo-ventricular opening, under cover of the coronary valve.

The **foramina Thebesii** are minute pore-like openings of small veins which issue directly from the muscular structure of the heart,

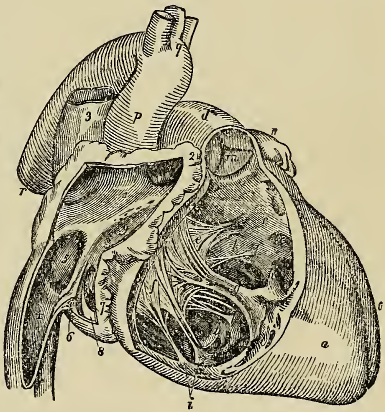


FIG. 356.—Anatomy of the heart: right side. 1. Cavity of right auricle. 2. Appendix auriculæ; in its cavity are seen the musculi pectinati. 3. Superior vena cava, opening into the upper part of right auricle. 4. Inferior vena cava. 5. Fossa ovalis; the prominent ridge surrounding it is the annulus ovalis. 6. Eustachian valve. 7. Opening of the coronary sinus. 8. Coronary valve. 9. Entrance of the auriculo-ventricular opening. Between the figures 1 and 9, two or three foramina Thebesii are seen. *a.* Right ventricle. *b, c.* Cavity of right ventricle, on the walls of which the columnæ carneæ are seen; *c* is placed in the channel leading upwards to the pulmonary artery, *d.* *e, f.* Tricuspid valve; *e* is placed on the anterior curtain, *f* on the right curtain. *g.* Musculus papillaris, to the apex of which the anterior and right curtain are connected by chordæ tendineæ. *h.* The "long moderator band." *i.* The two columnæ carneæ of the right curtain. *k.* Attachment by chordæ tendineæ of the left limb of the anterior curtain. *l, l.* Chordæ tendineæ of the "fixed curtain" of the valve. *m.* Valve of the pulmonary artery. The letter of reference is placed on the inferior semilunar segment. *n.* Apex of left appendix auriculæ. *o.* Left ventricle. *p.* Ascending aorta. *q.* Its transverse portion, with the three arterial trunks which arise from the arch. *r.* Descending aorta.

without entering the venous current. Similar openings are also found in the left auricle, and in the right and left ventricles, but, in the latter, they are commonly not the termination of vessels but mere cæcal depressions.

The **auriculo-ventricular opening** is the large opening of communication between the auricle and ventricle. It is oval in form, and admits three fingers easily.

The **Eustachian valve** is a part of the apparatus of fœtal circulation, and serves to direct the placental blood from the inferior

cava, through the foramen ovale into the left auricle. In the adult it is a mere vestige and imperfect, being often cribriform, though sometimes it remains of large size. It is formed by a fold of the lining membrane of the auricle, containing some muscular fibres, is situated between the aperture of the inferior cava and the auriculo-ventricular opening, and is continued into the outer part of the annulus ovalis.

The **coronary** or **Thebesian valve** is a semilunar fold of the lining membrane, stretching across the mouth of the coronary sinus, and preventing the reflux of blood in the vein during contraction of the auricle. It is insufficient to close the opening when the walls of the heart are relaxed, but is quite competent during their contraction, as the opening then becomes narrowed.

The **annulis ovalis** is situated on the septum auricularum, opposite the termination of the inferior cava. In the fœtus it formed the margin of an oval opening (**foramen ovale**) by which the two auricles communicated. In the adult the annulus is commonly incomplete below.

The **fossa ovalis** is an oval depression corresponding with the foramen ovale of the fœtus. This opening is closed at birth by a thin valvular layer, which is continuous with the left margin of the annulus, and is frequently imperfect at its upper part. The depression or fossa in the right auricle results from this arrangement. There is no fossa ovalis in the left auricle.

The **tubercle of Lower** is the portion of auricle intervening between the openings of the superior and inferior cava. Being thicker than the walls of the veins, it forms a projection, which was supposed by Lower to direct the blood from the superior cava into the auriculo-ventricular opening. It is better marked in the lower animals than in man.

The **musculi pectinati** are small muscular columns situated in the auricular appendix. They are numerous, and arranged parallel with each other; hence their cognomen *pectinati*, like the teeth of a comb.

The **RIGHT** or **ANTERIOR VENTRICLE** is triangular and prismoid in form. Its walls form the chief part of the anterior surface and lower border of the heart, and a small portion of the posterior surface. The posterior side, which is also inferior, is flat, and rests on the diaphragm; the inner side corresponds with the partition between the two ventricles, septum ventriculorum; the anterior side is convex. Superiorly where the pulmonary artery arises, there is a dilatation of the ventricle, termed the **infundibulum**, or **conus arteriosus**.

Dissection.—The right ventricle is to be laid open by grasping the wall with the left hand, transfixing it with the scalpel about half-way down, and carrying the incision onwards to the apex of the heart.

It contains, to be examined, two openings, the auriculo-ventricular and that of the pulmonary artery; two apparatus of valves,

tricuspid and semilunar; and a muscular and tendinous apparatus belonging to the tricuspid valves. They may be thus arranged :—

Auriculo-ventricular opening,	Tricuspid valve,
Opening of the pulmonary artery,	Semilunar valves.
Chordæ tendineæ,	
Columnæ carneæ.	

The **auriculo-ventricular opening** is surrounded by a fibrous ring, covered by the lining membrane (endocardium) of the heart. It is the opening of communication between the right auricle and ventricle.

The **opening of the pulmonary artery** is situated at the summit of the conus arteriosus, close to the septum ventriculorum, on the left side of the right ventricle, and upon the anterior aspect of the heart.

The **tricuspid valve** is formed by three triangular folds of the lining membrane, strengthened by a thin layer of fibrous tissue. They are connected by their base around the auriculo-ventricular opening; and by their sides and apices which are thickened, they give attachment to a number of slender tendinous cords, called chordæ tendineæ. The **chordæ tendineæ** are the tendons of the thick muscular columns (*columnæ carneæ*) which stand out from the walls of the ventricle, and serve as muscles to the valves. A number of these tendinous cords converge to a single muscular attachment. Of the three segments of which the valve is composed one is placed anteriorly, and is connected with the anterior wall, a second is placed against the posterior wall, while the third lies between the auriculo-ventricular opening and the commencement of the pulmonary artery; the first of these is attached by means of chordæ tendineæ to a papillary muscle springing from the anterior free wall of the cavity, the second is attached in like manner to a papillary muscle on the posterior wall, while the third is connected directly by its chordæ to the ventricular septum. Between the bases of these three flaps small intermediate folds are usually found. The chordæ tendineæ are attached not only to the margins of the valve segments, but also to the base and outer or ventricular surface; there are none, however, attached to the inner surface, over which the blood passes in its course from the auricle to the ventricle, so that this surface is smooth throughout, and friction is thus lessened. The tricuspid valves prevent the regurgitation of blood into the auricle during the contraction of the ventricle, and they are prevented from being themselves driven back by the chordæ tendineæ and their muscular attachments.

This connection of the muscular columns of the heart to the valves has caused their division into active and passive. The *active* valves are the tricuspid and mitral; the *passive*, the semilunar and coronary.

The **columnæ carneæ** (fleshy columns) is a name expressive of the appearance of the internal walls of the ventricles, which, with

the exception of the infundibulum, seem formed of muscular columns interlacing in almost every direction. They are divided, according to the manner of their connection, into three sets. 1. The greater number are attached by the whole of one side, and merely form convexities into the cavity of the ventricle. 2. Others are connected by both extremities, being free in the middle. 3. Two of larger size, called **musculi papillares,** are attached by one extremity to the walls of the heart, and by the other give insertion to the chordæ tendineæ. One of these is connected with the anterior and the other with the posterior wall of the ventricle. At the base of the anterior one a transverse fleshy band stretches across to the ventricular septum; it is called the *moderator band*, and is believed to strengthen the thin anterior wall by binding it to the firmer septum.

The **semilunar** or **sigmoid valves,** three in number, are situated around the commencement of the pulmonary artery, being formed by a folding of its lining membrane, strengthened by a thin layer of fibrous tissue. They are attached by their convex borders, and free by the concave, which are directed upwards in the course of the vessel, so that, during the current of the blood along the artery, they are pressed against the sides of the cylinder; but if regurgitation ensue, they are immediately expanded, and effectually close the entrance of the tube. The margins of the valves are thicker than the rest of their extent, and each valve presents in the centre of this margin a small fibro-cartilaginous tubercle or nodule, called **corpus Arantii,** which locks in with the other two during the closure of the valves, and secures the triangular space which would otherwise be left by the approximation of three semilunar folds. On each side of the nodule, the edge of the valve is folded and thin, and to this part the term *lunula* has been applied. When the valves are closed, the lunulæ are brought in contact with each other by their surfaces.

Between the semilunar valves and the cylinder of the artery are three pouches, called the **pulmonary sinuses** (sinuses of Valsalva). Similar sinuses are situated behind the valves at the commencement of the aorta, and are larger and more capacious than those of the pulmonary artery.

The **pulmonary artery** commences by a scalloped border, corresponding with the three valves which are attached along its edge. It is connected to the ventricle by muscular fibres, and by the lining membrane of the heart.

The **LEFT** or **POSTERIOR AURICLE** is somewhat thicker than the right; of a cuboid form, and situated more posteriorly. The *auricular appendix* is constricted at its junction with the auricle, and has a foliated appearance; it is directed forwards towards the root of the pulmonary artery, to which the auriculæ of both sides appear to converge.

Dissection.—The left auricle is to be laid open by a ⊥ shaped incision, the horizontal section being made along the border which

is attached to the base of the ventricle. It presents for examination five openings, and the muscular structure of the appendix : the fossa ovalis, as previously observed, is not to be seen on the left side of the septum auricularum. The parts to be examined are—

Four pulmonary veins,
Auriculo-ventricular opening,
Musculi pectinati.

The **pulmonary veins**, two from the right and two from the left lung, open into the back part of the auricle. The two left pulmonary veins terminate frequently by a common opening.

The **auriculo-ventricular opening** is the aperture of communication between the auricle and ventricle; it is oval in shape and is a little smaller than the corresponding opening on the right side.

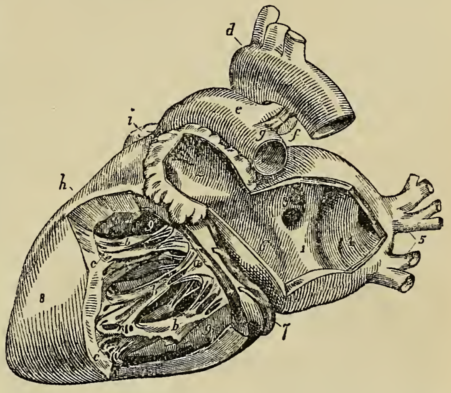


Fig. 357.—Anatomy of the heart: left side. 1. Cavity of left auricle. The figure is placed on that portion of the septum auricularum corresponding with the centre of the fossa ovalis. 2. Cavity of the auricular appendix, near the apex of which are seen musculi pectinati. 3. Opening of the two right pulmonary veins. 4. The sinus, into which the left pulmonary veins open. 5. Left pulmonary veins. 6. Auriculo-ventricular opening. 7. Coronary vein, lying in the auriculo-ventricular groove. 8. Left ventricle. 9, 9. Cavity of the left ventricle; the figures rest on the septum. *a.* Mitral valve; its flaps are connected by chordæ tendineæ to *b, b,* Columnæ carneæ. *c, c.* Fixed columnæ carneæ, forming part of the internal surface of the ventricle. *d.* Arch of the aorta, from the summit of which the three arterial trunks of the head and upper extremities are seen arising. *e.* Pulmonary artery. *f.* Obliterated ductus arteriosus; the letter is placed in the cleft formed by the bifurcation of the pulmonary artery. *g.* Left pulmonary artery. *h.* Right ventricle. *i.* Point of the appendix of right auricle.

The **musculi pectinati** are fewer in number than in the right auricle, and are situated only in the appendix auriculæ.

LEFT VENTRICLE.—The left ventricle is to be opened in the same manner as the right by transfixing its anterior wall close to the septum, and cutting downwards to the apex.

The left ventricle is conical both in external figure and in the shape of its internal cavity. It forms the apex of the heart, by projecting beyond the right ventricle, while the latter has the advantage in length towards the base. Its walls are about seven lines in thickness, those of the right ventricle being about two lines and a half.

It presents for examination, in its interior, two openings, two valves, and the tendinous cords and muscular columns; they may be thus arranged :—

Auriculo-ventricular opening,		Mitral valve,
Aortic opening,		Semilunar valves.
	Chordæ tendineæ,	
	Columnæ carneæ.	

The **auriculo-ventricular opening** is a dense fibrous ring covered by the endocardium, but smaller in size than that of the right side. Its fibrous structure is closely connected with that of the right auriculo-ventricular and aortic rings; at the junction of the three there is a fibro-cartilaginous mass, and, in some animals, a portion of bone.

The **mitral valve** is attached around the auriculo-ventricular opening, as is the tricuspid in the right ventricle. It is thicker than the tricuspid, and consists of two segments, of which the *anterior* is the largest and is placed between the auriculo-ventricular opening and the commencement of the aorta, and acts the part of a valve to that foramen during the filling of the ventricle. The *posterior* is placed behind and to the left of the auriculo-ventricular opening. The difference in size of the two valves, both being triangular, and the space between them, has given rise to the idea of a bishop's mitre, after which they are named. Two small secondary flaps are placed between the two larger ones. These valves, like the tricuspid, are furnished with an apparatus of tendinous chords, *chordæ tendineæ*, which are attached to two very large musculi papillares.

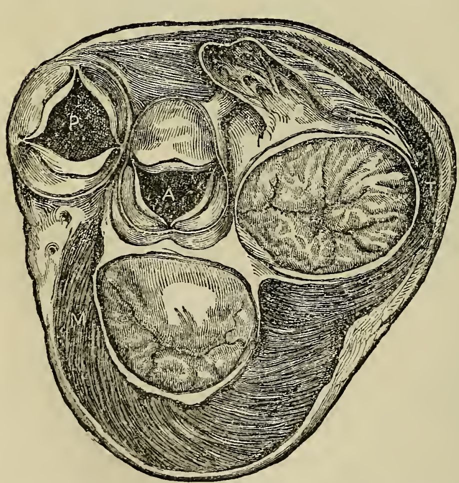


Fig. 358.—Section of heart at level of valves, as seen from above. P. Pulmonary artery. A. Aorta. M. Mitral valve. T. Tricuspid valve.

The **columnæ carneæ** admit of the same arrangement into three kinds as on the right side. Those which are free by one extremity, the musculi papillares, are two in number, and larger than those

on the opposite side, one being placed on the left wall of the ventricle, the other at the junction of the septum ventriculorum with the posterior wall.

The **semilunar valves** are placed around the commencement of the aorta, like those of the pulmonary artery; they are similar in structure, and are attached to the scalloped border by which the aorta is connected with the ventricle. The nodule in the centre of each fold is larger than those of the pulmonary valves, and it was these that Arantius particularly described; but the term **corpora Arantii** is now applied indiscriminately to both. The fossæ between the semilunar valves and the cylinder of the artery are larger than those of the pulmonary artery, and are called the **sinus aortici** (sinuses of Valsalva).

The part of the ventricle which leads upwards to the aorta is sometimes described as the **aortic vestibule** or **conus arteriosus**; its surface is smooth from the absence of columnæ carneæ, and from its walls containing a large amount of fibrous or fibro-cartilaginous tissue it does not collapse when the heart empties.

Position of the Heart in Relation to the Chest Wall.

Two-thirds of the heart lie to the left of the middle line, only the right auricle lying to the right of it; its extreme limit to the right is about one inch from the border of the sternum, and to the left two and a half inches from the edge of that bone. The upper margin of the auricles corresponds to a line drawn from the second right to the first left intercostal space. The *right auricle* lies behind the lower part of the sternum, its outer edge being situate at about an inch to the outer side of the right border of the bone. The *left auricle* lies on the left of the sternum, in a line running from the second left intercostal space to the upper border of the fourth left cartilage. The *right ventricle* extends from the third to the sixth cartilage of the left side near the sternum, the part nearest the surface being the conus arteriosus. The *left border*, formed by the left ventricle, may be defined by a line curved to the left, and extending from the edge of the sternum in the third left intercostal space, to the fifth space at about three and a half inches from the middle line. The *apex* of the heart, also formed by the left ventricle, is situated behind the fifth intercostal space, about two inches below the nipple, and half an inch to its inner side. The *right auriculo-ventricular opening* (tricuspid valve) corresponds to the middle of the sternum, on a line with the fourth costal cartilages. The *left auriculo-ventricular opening* (mitral valve) lies behind the third intercostal space of the left side at about an inch from the sternum. The *pulmonary opening* (pulmonary semilunar valves) is placed to the left of the sternum, on a level with the articulation of the third cartilage. The *aortic opening* (aortic semilunar valves) is placed lower than the pulmonary, and corresponds to the upper edge of the third intercostal space close to the

sternum. The valves are so situated that the mouth of a stethescope placed over the inner end of the third intercostal space of the left side will cover a portion of them all (Holden). A needle introduced into the second intercostal space close to the sternum, will pierce first the pleura and lung, then the pericardium, and next the ascending aorta ; introduced into the third, fourth, or fifth space, it will, after piercing the pleura and lung, enter the right auricle of the heart.

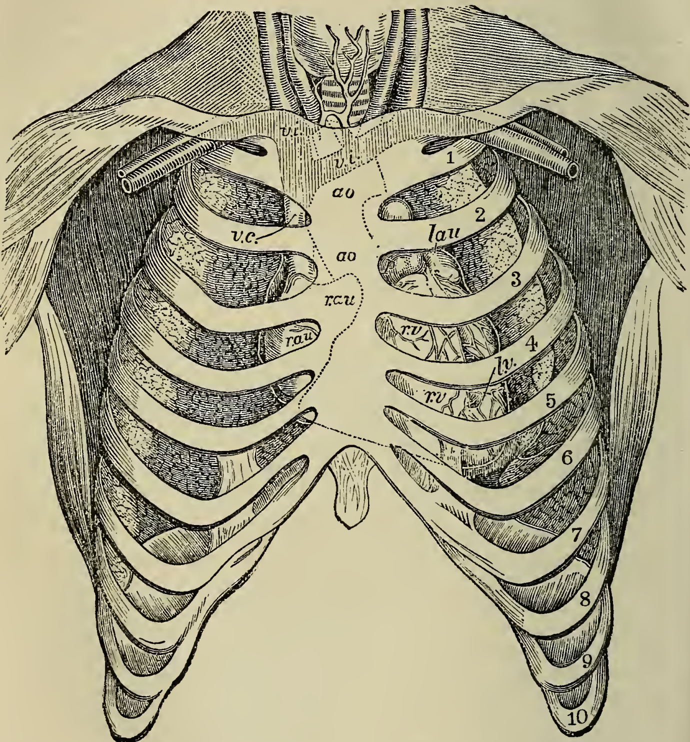


Fig. 359.—Position of the heart in relation to the chest walls. *v, i.* Innominate veins. *ao.* Aorta. *v, c.* Vena cava superior. *r. au.* Right auricle. *l. au.* Left auricle. *r. v.* Right ventricle. *l. v.* Left ventricle.

STRUCTURE OF THE HEART.

The heart is covered externally by a delicate serous membrane, the *pericardium,* and is lined within by another serous membrane, the *endocardium;* its walls consist for the most part of muscular

fibres, but with these there is a certain amount of fibrous and fibro-cartilaginous tissue, especially about the base and around the auriculo-ventricular and arterial openings.

Muscular Structure.

Ventricles.—The fibres of the ventricles have a very intricate arrangement. The most recent and complete description is that of Dr. Pettigrew, in the *Philosophical Transactions* for 1864. The author shows that the wall of the ventricles may be divided into seven layers, the fibres of which differ in direction. The fibres of the first layer run spirally downwards from left to right, but nearly vertically; those of the second layer take the same general direction, but are more inclined to the horizontal; those of the third layer are still more transverse, and the fourth layer is quite transverse. Passing the fourth layer, which occupies a central position in the ventricular walls and forms the boundary between the external and internal layers, the order of arrangement is reversed and the fibres of the remaining layers, viz., five, six, and seven, gradually return in an opposite direction and in an inverse order to the same relation to the vertical as that maintained by the first external layer. The fibres composing corresponding external and internal layers, such as layers one and seven, two and six, &c., are continuous in the left ventricle at the apex, and in the right ventricle in the track for the anterior coronary artery, the fibres of both ventricles being for the most part continuous likewise at the base. The fibres of the right and left ventricles anteriorly and septally are to a certain extent independent of each other; whereas posteriorly many of them are common to both ventricles; *i.e.*, the fibres pass from one ventricle to the other. At the apex the fibres are twisted round like a scroll or whorl, and then the external fibres enter into the interior of the ventricle, and some of them are continuous with those of the musculi papillares, others with the innermost layer of spinal fibres. The fibres from the back and front of the ventricle enter the apex in two different bundles, so that the whorl is composed of a double set of fibres twisted round each other something like the fingers of the two hands when they are folded over each other and closed.

Auricles.—The muscular fibres of the auricles are disposed in three sets—transverse, spiral, and circular. The transverse are most external and extend over both cavities entering the septum. The spiral are attached at each extremity to the auriculo-ventricular rings; they are looped and irregular in their arrangement, and are common to both auricles. The circular begin at the apex of the appendix and are continued on to the body of the auricle; they have on their interior a number of fibres which are arranged longitudinally. The circular fibres belonging to each auricle are distinct from those of its fellow. Other fibres surround the entrance of the venæ cavæ and pulmonary veins and are continued for some distance along these vessels.

Minute Structure.

The **pericardium** is a thin layer, composed of a network of fine elastic fibres, adherent by the deep surface to the muscular structure of the heart, and supporting on its free surface a single or double lamina of tesselated epithelium. Beneath the pericardium, especially in the grooves of the heart, is more or less adipose tissue, which is sometimes distributed more extensively over the surface of the organ.

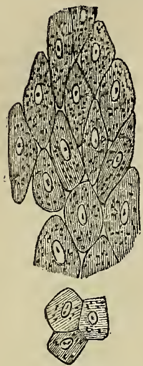


Fig. 360. — Epithelium of the endocardium.

The **endocardium**, or lining membrane of the heart, is also thin, but thicker in the auricles than in the ventricles, and especially in the left auricle. It consists of three layers—namely, (1) a thin stratum of white fibrous areolar tissue, which connects it to the muscular structure; (2) a middle layer, composed of elastic tissue, which is so abundant in the auricles as to constitute a thin elastic membrane possessed of several laminæ; and (3) an epithelium, consisting of a single or double layer of more or less elongated or polygonal, flattened nucleated cells. The surface of the middle layer, on which the epithelium is embedded, presents a smooth stratum of fine elastic fibres, arranged longitudinally, while the chief thickness of the layer is made up of fine and coarse elastic networks, connected by a matrix of areolar tissue, in the meshes of which are numerous scattered nuclei. Muscular fibres similar to those of the wall of the heart are also found in certain parts. In the ventricles the endocardium is transparent; in the auricles, particularly the left, it is opaque and white; it is continuous with the lining membrane of the vessels which open into the heart.

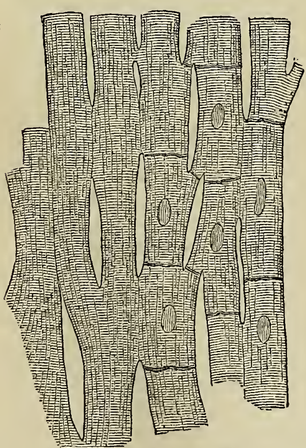


Fig. 361.—Anastomosing muscular fibres of heart. On the right the cells and nuclei are seen.

The **muscular structure** of the heart presents certain peculiarities which distinguish it both from the striated and non-striated fibres described on a previous page, although the presence of transverse markings leads to its being classed with the first of these two forms. The striæ are more faintly marked than those of ordinary striped muscle, and the fibres are smaller, and have no sarcolemma; they are re-

markable for their numerous branches and frequent anastomoses, and are formed by the union of distinct cells joined end to end. Each cell has a single nucleus near its centre and one or two nucleoli; they frequently contain small fatty granules which are greatly multiplied in fatty degeneration of the heart.

The **auriculo-ventricular valves** are composed of two layers of endocardium, connected in the body of the valve by areolo-fibrous tissue, mingled with a network of elastic fibres; towards the edges of the valve, the two layers become blended with each other, and form a single membrane. The *chordæ tendineæ* consist of a fasciculus of tendinous fibres invested by a thin layer of endocardium. The *semilunar valves* are composed of a thin stratum of elastic and areolar tissue, the elastic tissue forming a fine network in the substance of the latter, and the free surface being invested by a single or double layer of epithelium.

Vessels and Nerves.—The *arteries* of the heart are derived from the left and right coronary; the *capillaries* form a fine network around the muscular fasciculi as in other muscles; the *veins* accompany the arteries, and empty themselves by the common coronary vein into the right auricle; the venæ minimæ or venæ Thebesii discharging their blood directly into the auricle. The semilunar valves are an exception to the rest of the valves of the heart, in having no blood-vessels. *Lymphatic vessels* are scanty in the bag of the pericardium, but numerous beneath the visceral layer; they follow the grooves of the heart, and terminate in the glands situated beneath the arch of the aorta, and upon the bifurcation of the trachea.

The *nerves* of the heart are numerous, and derived from the cardiac plexuses, which are formed by filaments from the sympathetic and pneumogastric nerve, and reach the substance of the organ by means of the anterior and posterior coronary plexus. The nervous filaments partly accompany the vessels, partly cross their course, anastomose with each other at acute angles, and pierce the surface of the heart to reach its substance and the endocardium. The nerves are grey, being composed of fine pale fibres, a few only of the larger nerves containing in addition an admixture of nucleated fibres. Where the nerve filaments intersect each other there are minute ganglionic enlargements, which receive the name of *ganglia of Remak.*

Size and Weight of the Heart.—Roughly stated, the heart is about equal in size to the closed fist of the individual; it measures about five inches in length, three and a half in greatest width and two and a half in greatest thickness. The average weight of the heart in the male is ten to eleven ounces, and in the female about nine ounces.

Fœtal Heart and Fœtal Circulation.

Fœtal Heart.—At the time of birth the heart is large in proportion to the size of the body; the walls of the two ventricles are of nearly equal thickness, and are relatively thicker than in adult

life; the right and left auricle communicate by an oval opening, **foramen ovale** (Foramen of Botal). Both ventricles pour their blood into the aorta, this being accomplished in the case of the right ventricle by means of a trunk connecting the pulmonary artery with the junction of the transverse and descending parts of the arch, **ductus arteriosus**; the Eustachian valve is large, and serves to

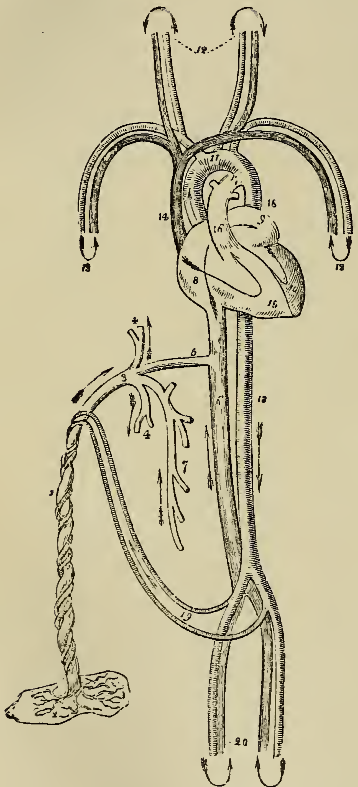


FIG. 362.—Fœtal circulation. 1. Umbilical cord, consisting of umbilical vein and two umbilical arteries, proceeding from the placenta (2). 3. Umbilical vein, dividing into branches; two (4, 4), to be distributed to the liver, and one (5), the ductus venosus, which enters the inferior vena cava (6). 7. Portal vein, returning the blood from the intestines, and communicating with the right hepatic branch. 8. Right auricle; the course of the blood is denoted by the arrow, proceeding from 8, to 9, the left auricle. 10. Left ventricle, the blood following the arrow to the arch of the aorta (11), to be distributed through the branches given off by the arch to the head and upper extremities. The arrows 12 and 13, represent the return of the blood from the head and upper extremities through the jugular and subclavian veins, to the superior vena cava (14), to the right auricle (8), and in the course of the arrow through the right ventricle (15), to the pulmonary artery (16). 17. Ductus arteriosus, which appears to be a proper continuation of the pulmonary artery; the offsets at each side are the right and left pulmonary artery, these are of extremely small size as compared with the ductus arteriosus. The ductus arteriosus joins the descending aorta (18, 18), which divides into the common iliacs, and these into the internal iliacs, or hypogastric arteries (19) and return the blood along the umbilical cord to the placenta; while the other divisions, the external iliacs (20), are continued into the lower extremities. The arrows at the terminations of these vessels mark the return of the venous blood by the veins to the inferior cava.

prevent the blood from the inferior cava passing into the auriculo-ventricular opening, directing it into the foramen ovale.

Fœtal Circulation.—The pure blood is brought from the placenta by the **umbilical vein**. The umbilical vein passes through the umbilicus and enters the liver, where it divides into several branches; two or three of these branches are distributed to the left lobe, one branch communicates with the portal vein in the transverse fissure and supplies the right lobe, and a large branch, the **ductus venosus**,

passes directly backwards and joins the inferior vena cava. In the inferior cava the pure blood becomes mixed with that which is returning from the lower extremities and abdominal viscera, and is carried through the right auricle (guided by the Eustachian valve) and through the **foramen ovale** into the left auricle. From the left auricle it passes into the left ventricle, and from the left ventricle into the aorta, whence it is distributed by means of the carotid and subclavian arteries, principally to the head and upper extremities. From the head and upper extremities the impure blood is returned by the superior vena cava to the right auricle ; from the right auricle it is propelled into the right ventricle, and from the right ventricle into the pulmonary artery. In the adult, the blood would now be circulated through the lungs and oxygenated, but in the fœtus the lungs are solid and almost impervious. Only a small quantity of blood passes therefore into the lungs, the greater part courses through the **ductus arteriosus** into the commencement of the descending aorta, where it becomes mingled with a very small portion of the pure blood derived from the left ventricle.

Passing along the aorta, a small quantity of this mixed blood is distributed by the external iliac arteries to the lower extremities ; the greater portion is conveyed by the internal iliac, or hypogastric, and umbilical arteries to the placenta ; the hypogastric arteries pass forwards by the side of the fundus of the bladder, and upwards along the anterior wall of the abdomen to the umbilicus, where they become the umbilical arteries.

From a careful consideration of this circulation, we perceive—1st. That the pure blood from the placenta is distributed in considerable quantity to the liver, before entering the general circulation. Hence arises the abundant nutrition of that organ, and its enormous size in comparison with other viscera.

2dly. That the right auricle is the scene of meeting of a double current ; the one coming from the inferior cava, the other from the superior, and that they must cross each other in their respective course. How this crossing is effected, a cursory examination of the fœtal heart will show ; for the direction of entrance of the two vessels is so opposite, that they may discharge their currents through the same cavity with very little admixture. The inferior cava opens almost directly into the left auricle ; and, by the aid of the Eustachian valve, the current in the cava is almost entirely excluded from the right auricle.

3dly. That the blood which circulates through the arch of the aorta comes directly from the placenta ; and although mixed with the impure blood of the inferior cava, yet is propelled in such abundance to the head and upper extremities, as to provide for the increased nutrition of those parts, and prepare them, by their greater size and development, for the functions which they are required to perform at the instant of birth.

4thly. That the blood circulating in the descending aorta is very impure, being obtained principally from the returning current in

the superior cava; a small quantity only being derived from the left ventricle. Yet it is from this impure blood that the nutrition of the lower extremities is provided. Hence we are not surprised at their insignificant development at birth; while we perceive the providence of nature, which directs the nutrient current, in abundance, to the organs of sense, prehension, and deglutition, organs so necessary, even at the instant of birth, to the safety and welfare of the creature.

After birth, the *foramen ovale* becomes gradually closed by a membranous layer, which is developed from the margin of the opening on the left side and from below upwards, and completely separates the two auricles. The situation of the foramen is seen in the adult heart, on the septum auricularum, and is called the *fossa ovalis;* the prominent margin of this opening is the *annulus ovalis.*

As soon as the lungs have become inflated by the first act of inspiration, the blood of the pulmonary artery courses through its right and left branches into the lungs, to be returned to the left auricle by the pulmonary veins. Thus the pulmonary circulation is established. Then the *ductus arteriosus* contracts and degenerates into an impervious fibrous cord, serving in after-life simply as a bond of union between the left pulmonary artery and the concavity of the arch of the aorta.

The current through the umbilical cord being arrested, the *hypogastric arteries* likewise contract and become impervious. The *umbilical vein* and *ductus venosus*, also deprived of their circulating current, become reduced to fibrous cords, the former being the *round ligament* of the liver, and the latter a fibrous band which may be traced along the fissure of the ductus venosus to the inferior vena cava.

ORGANS OF RESPIRATION AND VOICE.

The organs of respiration are the two lungs, with their air-tube, the trachea, to the upper part of which is adapted an apparatus of cartilages, constituting the organ of voice, or larynx.

THE LARYNX.

The larynx is situated at the fore-part of the neck, between the trachea and base of the tongue. It is a short tube, of an hour-glass form, and is composed of *cartilages*, *ligaments*, *muscles*, *vessels*, *nerves*, and *mucous membrane.*

The **cartilages** are nine in number, three of which are single and placed in the middle line; the other six are arranged in three pairs placed symmetrically on each side. They are the—

Thyroid,	Two cornicula laryngis,
Cricoid,	Two cuneiform,
Two arytenoid,	Epiglottis.

The **thyroid** (*θυρεὸς εἶδος*, like a shield) is the largest cartilage of the larynx: it consists of two lateral portions, or **alæ**, which meet at an angle in front, and form the projection which is known by the name of **pomum Adami.** In the male, after puberty, the angle of union of the two alæ is acute; in the female, and before puberty in the male, it is obtuse. When the pomum Adami is prominent, a bursa mucosa is often found between it and the skin.

Each ala is quadrilateral in shape, and forms a rounded border posteriorly, which terminates above, in the **superior cornu**, and below, in the **inferior cornu**; the former pass upwards and slightly backwards, and are connected by means of the thyro-hyoid ligaments with the extremities of the greater cornua of the os hyoides; the latter curve downwards and inwards, and terminate by a smooth facet, by means of which they articulate with the lateral aspect of the cricoid cartilage. On the side of the ala is an **oblique line**, or **ridge**, directed downwards and forwards, and bounded at each extremity by a tubercle. Into this line the sterno-thyroid muscle is inserted; and from it the thyro-hyoid and inferior constrictor take their origin. In the *receding angle*, formed by the meeting of the two alæ, on the inner side of the cartilage, and near its lower border, are attached the epiglottis, vocal cords, thyro-arytenoid and thyro-epiglottidean muscles.

The **cricoid** (*κρίκος εἶδος*, like a ring) is a ring of cartilage, narrow in front, and broad behind, where it is surmounted by *two rounded surfaces*, which articulate with the arytenoid cartilages. At the middle line, posteriorly, is a *vertical ridge* which gives attachment to the œsophagus, and at each side of the ridge are the depressions which lodge the crico-arytenoidei postici muscles. On either side of the ring is a *glenoid cavity*, which articulates with the inferior cornu of the thyroid cartilage.

The **arytenoid cartilages** (*ἀρυταίνα*,* a pitcher), two in number, are triangular and prismoid in form. They are broad and thick below where they articulate with the upper border of the cricoid cartilage; pointed above, and prolonged by two small pyriform fibro-cartilages, **cornicula laryngis** (capitula Santorini), which are curved inwards and backwards, and they each present three surfaces, anterior, posterior, and internal. The posterior surface is concave, and lodges part of the arytenoideus muscle; the internal surface is smooth, and forms parts of the lateral wall of the larynx; the anterior or external surface is rough and uneven, and gives attachment to the vocal cord, thyro-arytenoideus, crico-arytenoideus lateralis and posticus.

The **cuneiform cartilages** (cartilages of Wrisberg) are two small cylinders of yellow fibro-cartilage, about seven lines in length, and enlarged at each extremity. They lie in the fold of mucous mem-

* This derivation has reference to the appearance of both cartilages taken together and covered by mucous membrane. In animals, which were the principal subjects of dissection among the ancients, the opening of the larynx, with the arytenoid cartilages, bears a curious resemblance to the mouth of a pitcher with a large spout.

made of Yellow fibrous Cartilage

brane extending from the apex of the arytenoid cartilages, to the sides of the epiglottis.

In the male, the cartilages of the larynx are more or less ossified, particularly in old age.

The **epiglottis** (ἐπιγλωττὶς, upon the tongue) is a fibro-cartilage of a yellowish colour, studded with a number of small mucous glands, which are lodged in shallow pits on its surface. It is shaped like an obcordate leaf, and placed immediately in front of the opening of the larynx, which it partly closes when the larynx is drawn up beneath the base of the tongue. It is attached by its point to the *receding angle* of the thyroid cartilage by means of fibrous tissue forming the *thyro-epiglottic ligament*, and to the inner surface of the body of the hyoid bone by the *hyo-epiglottic ligament;* with the base of the tongue it is connected by folds of mucous membrane forming the *frenula*, or *glosso-epiglottidean* folds, and with the summit of the arytenoid cartilages by the *aryteno-epiglottidean folds.* Its laryngeal surface is concavo-convex from above downwards, and concave from side to side; the convex portion projects into the anterior part of the upper opening of the larynx, and is called the **cushion of the epiglottis.**

Ligaments.—The *ligaments* of the larynx are numerous, and may be arranged into four groups: 1. Those which articulate the thyroid with the os hyoides. 2. Those which connect it with the cricoid. 3. Ligaments of the arytenoid cartilages. 4. Ligaments of the epiglottis.

1. The ligaments which connect the thyroid cartilage with the os hyoides are three in number.

Two **thyro-hyoid ligaments** pass between the superior cornua of the thyroid and the extremities of the greater cornua of the os hyoides; they are composed of yellow fibrous tissue, and often contain a sesamoid bone or cartilage (cartilago triticea).

The **thyro-hyoid membrane** is a broad membranous layer, occupying the entire space between the upper border of the thyroid cartilage and the upper and inner border of the os hyoides. It is pierced by the superior laryngeal nerve and artery.

2. The ligaments connecting the thyroid to the cricoid cartilage are also three in number:—

Two **capsular ligaments**, with their synovial membranes, which form the articulation between the inferior cornua of the thyroid and the sides of the cricoid; and the crico-thyroid membrane.

The **crico-thyroid membrane** is a fan-shaped layer of yellow elastic tissue, thick in front (middle crico-thyroid ligament) and thinner at each side (lateral crico-thyroid ligament). It is attached by its apex to the lower border and receding angle of the thyroid cartilage, and by its expanded margin to the upper border of the cricoid and base of the arytenoid cartilages. Superiorly it is continuous with the inferior margin of the vocal cords. The front of the crico-thyroid membrane is crossed by a small artery, the inferior laryngeal, and is the spot selected for the operation of laryngotomy.

Laterally it is covered in by the crico-thyroid and lateral crico-arytenoid muscles.

3. The ligaments of the arytenoid cartilages are eight in number :—

Two **capsular ligaments,** with synovial membranes, which articulate the arytenoid cartilages with the cricoid, strengthened behind by two *posterior crico-arytenoid* bands or ligaments; and the superior and inferior thyro-arytenoid ligaments.

The **superior thyro-arytenoid ligaments** are two scattered bands of fibres attached in front to the receding angle of the thyroid cartilage, and behind to the anterior and inner border of each arytenoid cartilage, and contained in the folds of mucous membrane

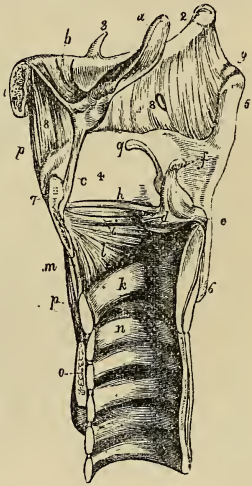


Fig. 363.—Vertical section of the larynx, showing its ligaments. 1. Body of os hyoides. 2. Its great cornu. 3. Lesser cornu. 4. Ala of the thyroid cartilage. 5. Superior cornu. 6. Inferior cornu. 7. Pomum Adami. 8, 8. Thyro-hyoid membrane; the opening in the membrane immediately above the posterior figure is for the passage of the superior laryngeal nerve and artery. 9. Thyro-hyoid ligament; the figure is placed immediately above the sesamoid bone or cartilage. *a.* Epiglottis. *b.* Hyo-epiglottic ligament. *c.* Thyro-epiglottic ligament. *d.* Arytenoid cartilage; inner surface. *e.* Outer angle of base of arytenoid cartilage. *f.* Corniculum laryngis. *g.* Cuneiform cartilage. *h.* Superior thyro-arytenoid ligament. *i.* Inferior thyro-arytenoid ligament, or true vocal cord; the elliptical space between the two thyro-arytenoid ligaments is the ventricle of the larynx. *k.* Cricoid cartilage. *l.* Lateral portion of the crico-thyroid membrane. *m.* Central portion of the same membrane. *n.* Upper ring of trachea. *o.* Section of isthmus of thyroid gland. *p*, *p*. Levator glandulæ thyroideæ.

constituting the false vocal cords. The lower border of this ligament constitutes the upper boundary of the ventricle of the larynx.

The **inferior thyro-arytenoid ligaments**, or true **vocal cords,** are thicker than the superior, and are composed of yellow elastic tissue. Each ligament is attached in front to the receding angle of the thyroid cartilage, and behind to the anterior angle of the base of the arytenoid. The inferior border of the vocal cord is continuous with the lateral expansion of the crico-thyroid ligament. The superior border forms the lower boundary of the ventricle of the larynx. The space between the two vocal cords is the glottis or rima glottidis.

4. The ligaments of the epiglottis are five in number—namely, three glosso-epiglottic, hyo-epiglottic, and thyro-epiglottic.

The **glosso-epiglottic** ligaments (fræna epiglottidis) are three

folds of mucous membrane, which connect the anterior surface of the epiglottis with the root of the tongue. The middle of these contains elastic tissue. The **hyo-epiglottic** ligament is a band of yellow elastic tissue passing between the anterior aspect of the epiglottis near its apex, and the upper margin of the body of the os hyoides. The **thyro-epiglottic** ligament is a long and slender fasciculus of yellow elastic tissue, which embraces the apex of the epiglottis, and is inserted into the receding angle of the thyroid cartilage immediately below the anterior fissure and above the attachment of the vocal cords.

Muscles.—The intrinsic muscles of the larynx are eight in number; the five larger are the muscles of the vocal cords and rima glottidis; the three smaller are muscles of the epiglottis.

The five muscles of the vocal cords and rima glottidis are—

Crico-thyroid,	Thyro-arytenoideus,
Crico-arytenoideus posticus,	Arytenoideus.
Crico-arytenoideus lateralis,	

The **crico-thyroid** muscle *arises* from the anterior surface of the cricoid cartilage, and passes obliquely outwards and backwards to be *inserted* into the lower and inner border of the ala of the thyroid from its tubercle as far back as the inferior cornu. Some of its fibres are continuous with those of the inferior constrictor of the pharynx.

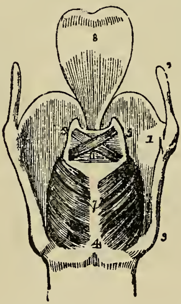


FIG. 364.—Posterior view of the larynx. 1. Thyroid cartilage, right ala. 2. Ascending cornu. 3. Descending cornu. 4, 7. Cricoid cartilage. 5, 5. Arytenoid cartilages. 6. Arytenoideus muscle, consisting of oblique and transverse fasciculi. 7. Crico-arytenoidei postici muscles. 8. Epiglottis.

The **crico-arytenoideus posticus** *arises* from the depression on the posterior surface of the cricoid cartilage, and passes upwards and outwards to be *inserted* into the outer angle of the base of the arytenoid.

The **crico-arytenoideus lateralis** *arises* from the upper border of the side of the cricoid, and passes upwards and backwards to be *inserted* into the outer angle of the base of the arytenoid cartilage.

The **thyro-arytenoideus** is situated above the preceding muscle; it *arises* from the receding angle of the thyroid cartilage, close to the outer side of the true vocal cord, and passes backwards parallel with the cord, to be *inserted* into the base and outer and anterior surfaces of the arytenoid cartilage, and to the mucous membrane covering the true vocal cord.

The **arytenoideus** muscle occupies the posterior concave surface of the arytenoid cartilages, between which it is stretched. It consists of three planes of transverse and oblique fibres; hence it was formerly considered as several muscles, under the names of *transversi* and *obliqui*.

The three muscles of the epiglottis are—

Thyro-epiglottideus, Aryteno-epiglottideus superior,
Aryteno-epiglottideus inferior.

The **thyro-epiglottideus** appears to be formed by the upper fibres of the thyro-arytenoideus muscle; they spread out on the external surface of the sacculus laryngis, and in the aryteno-epiglottidean fold of mucous membrane, on which they are lost; a few of the anterior fibres being continued onwards to the side of the epiglottis (depressor epiglottidis).

The **aryteno-epiglottideus superior** consists of a few scattered muscular fibres, which pass forward in the fold of mucous membrane forming the lateral boundary of the entrance into the larynx, from the apex of the arytenoid cartilage to the side of the epiglottis.

The **aryteno-epiglottideus inferior**, closely connected with the sacculus laryngis, may be seen by raising the mucous membrane immediately above the ventricle of the larynx. It *arises* by a narrow and fibrous origin from the arytenoid cartilage, just above the attachment of the vocal cord; and passing forwards and a little upwards expands over the upper half or two-thirds of the sacculus laryngis; it is *inserted* by a broad attachment into the side of the epiglottis.

Actions.—The crico-arytenoidei postici open the glottis while all the rest close it. The arytenoideus approximates the arytenoid cartilages posteriorly, and the crico-arytenoidei laterales and thyro-arytenoidei anteriorly; the latter, moreover, close the glottis mesially. The crico-thyroidei are tensors of the vocal cords, and these muscles, together with the thyro-arytenoidei, regulate the tension, position, and vibrating length of the vocal cords.

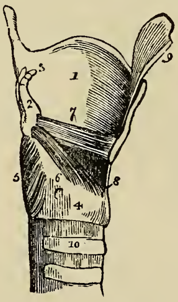


FIG. 365.—Side view of larynx, one ala of the thyroid cartilage removed. 1. Left ala of thyroid cartilage. 2. Right arytenoid cartilage. 3. Corniculum laryngis. 4. Cricoid cartilage. 5. Crico-arytenoideus posticus muscle. 6. Crico-arytenoideus lateralis. 7. Thyro-arytenoideus. 8. Crico-thyroid membrane. 9. One half the epiglottis. 10. Upper part of trachea.

The crico-thyroid muscles effect the tension of the vocal cords by rotating the inferior cornua of the thyroid on the cricoid; by this action the anterior portion of the thyroid is drawn downwards, and made to approximate the upper edge of the cricoid, thus separating it further from the arytenoid to which the vocal cords are fixed. The crico-arytenoidei postici separate the vocal cords by drawing the outer angles of the arytenoid cartilages outwards and downwards. The crico-arytenoidei laterales, by drawing the outer angles of the arytenoid cartilages forwards, approximate the anterior angles to which the vocal cords are attached. The thyro-arytenoidei draw the arytenoid cartilages forwards, and, by their connection with the vocal cords, make the whole length or any segment of the cords tense.

The thyro-epiglottideus acts principally by compressing the glands of the sacculus laryngis and the sac itself: by its attachment to the epiglottis it would act feebly upon that valve. The aryteno-epiglottideus superior serves to keep the mucous membrane of the sides of the opening of the glottis tense, when the larynx is drawn upwards and the opening closed by the epiglottis. Of the aryteno-epiglottideus, the functions appear to be, to compress the subjacent glands which open into the pouch; to diminish the capacity of that cavity, and change its form; and to approximate the epiglottis and the arytenoid cartilage.

Mucous Membrane.—The aperture of the larynx is a triangular or cordiform opening, broad in front and narrow behind; bounded anteriorly by the epiglottis, posteriorly by the arytenoideus muscle, and on either side by a fold of mucous membrane stretched between the side of the epiglottis and the apex of the arytenoid cartilage. On the margin of this **aryteno-epiglottidean** fold the cuneiform cartilage forms a prominence more or less distinct. The cavity of the larynx is divided into two parts by an oblong constriction produced by the prominence of the vocal cords. That portion of the cavity which lies above the constriction is broad and triangular above, and narrow below; that which is below it, is narrow above and broad and cylindrical below, the circumference of the cylinder corresponding with the ring of the cricoid; while the space included by the constriction is a narrow, triangular fissure, the **glottis** or **rima glottidis.** The form of the glottis is that of an isosceles triangle, bounded on the sides by the vocal cords and inner surface of the arytenoid cartilages, and behind by the arytenoideus muscle; the part of the chink of the glottis which lies between the vocal cords is often described as the *vocalising area*, and the smaller posterior portion as the *respiratory area.* Its length is greater in the male than in the female, and in the former measures somewhat less than an inch. Immediately above the prominence caused by the vocal cord, and extending nearly its entire length on each side of the cavity of the larynx, is an elliptical fossa, the **ventricle of the larynx.** This fossa is bounded below by the true vocal cord, which it serves to isolate, and above by a border of mucous membrane folded upon the lower edge of the superior thyro-arytenoid ligament (superior or false vocal cord). The whole of the cavity of the larynx, with its prominences and depressions, is lined by mucous membrane, which is continuous superiorly with that of the mouth and pharynx, and inferiorly is prolonged through the trachea and bronchial tubes into the lungs. In the ventricles of the larynx the mucous membrane forms a cæcal pouch of variable size, termed the **sacculus laryngis.** The sacculus laryngis is directed upwards, sometimes extending as high as the upper border of the thyroid cartilage, and occasionally above that border. When dissected from the interior of the larynx it is found covered by the aryteno-epiglottideus muscle and a fibrous membrane, which latter is attached to the superior thyro-arytenoid ligament below; to the epiglottis in

front; and to the upper border of the thyroid cartilage above. If examined from the exterior of the larynx, it will be seen to be covered by the thyro-epiglottideus muscle. On the surface of its mucous membrane are the openings of sixty or seventy small racemose glands, which are situated in the sub-mucous tissue, and give to its external surface a rough and ill-dissected appearance. The secretion from these glands is intended for the lubrication of the vocal cords, and is directed upon them by two small valvular folds of mucous membrane, which are situated at the entrance of the sacculus. The mucous membrane is closely connected to the epiglottis and to the vocal cords, on the latter being remarkable for its thinness. It is invested by a columnar ciliated epithelium as high up as the superior folds of the ventricle of the larynx and lower half of the epiglottis, but on the true vocal cords the epithelium is squamous and non-ciliated.

Glands.—The mucous membrane of the larynx is furnished with an abundance of mucous glands; many of these are situated on the epiglottis, in the sacculus laryngis, and in the aryteno-epiglottidean folds, where they are termed *arytenoid*. The body known as the epiglottic gland is merely a mass of areolar and adipose tissue, situated in the triangular space between the front surface of the apex of the epiglottis, the hyo-epiglottic, and the thyro-hyoid ligament.

Laryngoscopic Appearance.—When examined by means of the laryngoscope, the upper opening of the larynx presents the appearance of a space of almost semilunar form, bounded in front by the base of the tongue and behind by the wall of the pharynx. In the anterior part of this space the curved free extremity of the epiglottis (fig. 366, *e*) is seen, and projecting into the space from before, in the middle line, the cushion of the epiglottis (*cu*). In the middle line behind is a narrow slit, which is the space between the two arytenoid cartilages, and on each side of this a rounded tubercle, the tip of each cornicula laryngis; a little externally to these, two other tubercles will be noticed, due to the presence of the cuneiform cartilages, and running from them outwards to the edges of the epiglottis, two crescentic folds of mucous membrane, the aryteno-epiglottidean folds. In the middle of the space, four flattened bands will be seen, two on each side; these are the true (*ivc*) and false (*svc*) vocal cords; between the former lies the narrow chink or fissure of the glottis.

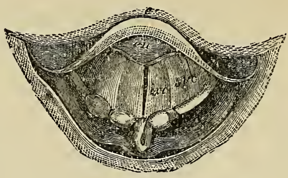


Fig. 366.—Laryngoscopic view of the glottis during the emission of a high note. *e.* Epiglottis. *cu.* Cushion of the epiglottis. *ivc.* True vocal cord. *svc.* False vocal cord.

Vessels and Nerves.—The *arteries* of the larynx are derived from the superior and inferior thyroid. The *nerves* are the superior laryngeal and recurrent laryngeal; both branches of the pneumo-

gastric. The two nerves communicate with each other, but the superior laryngeal is distributed principally to the mucous membrane at the entrance of the larynx; the recurrent to the muscles.

THE TRACHEA.

The trachea or wind-pipe is cylindrical for about two-thirds of its circumference, and flattened on the posterior third, where it rests on the œsophagus; it extends from opposite the fifth cervical vertebra to opposite the third dorsal, where it divides into the two bronchi. The length of the trachea is about four inches, and its diameter from side to side nearly an inch; it is somewhat larger in the male than in the female. The **right bronchus**, larger than the left, passes off nearly at *right angles* to the upper part of the corresponding lung. The **left** descends *obliquely*, and passes beneath the arch of the aorta, to reach the left lung.

It is composed of cartilaginous rings, fibrous membrane, muscular fibres, elastic tissue, and is lined by mucous membrane.

The **cartilaginous rings** are from fifteen to twenty in number, and extend for two-thirds around its cylinder, being deficient at the posterior part. The first ring is received within the lower margin of the cricoid cartilage, and is broader than the rest; the last is broad at the middle in consequence of the prolongation of the lower border into a triangular process which curves backwards at the point of bifurcation. The posterior extremities of the rings are rounded, and occasionally one or two rings will be found to bifurcate. The outer surface of each ring is flat, the inner is convex from above downwards.

The **fibrous membrane** connects the rings and forms a thin covering to them on the outer surface. Internally it does not reach the surface, and the rings have in consequence an appearance of greater prominence. It also stretches across between the rings on the posterior part of the trachea.

The **muscular fibres** are disposed transversely across the space, between the extremities of the rings behind. They are placed internally to the fibrous membrane. Outside the circular fibres are a few running longitudinally; they are connected with the inner surface of the ends of the rings, and with the external fibrous membrane.

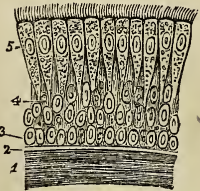


Fig. 367.—Ciliated epithelium from the trachea. 1. External layer of longitudinal elastic fibres. 2. Basement membrane. 3. Round cells. 4. Oval and oblong cells. 5. Ciliated cells.

The **elastic tissue** forms the **submucous tissue**, and is disposed in longitudinal bundles within the rings, and internally to the muscular layer behind. It is most developed opposite the bifurcation of the trachea.

The **mucous membrane**, which is pale, forms the internal lining

of the tube, and has opening upon its surface the excretory tubes of numerous mucous glands, the glands themselves lying external to the muscular coat; it is furnished with a ciliated columnar epithelium, which is continuous with that of the larynx above and the bronchial tubes below. The mucous membrane contains a large amount of lymphoid tissue.

The **mucous glands** are small ovoid bodies situated internally to the fibrous membrane, between that membrane and the muscular layer behind, and in the substance of the fibrous membrane between the rings. Their ducts open upon the mucous membrane.

The **bronchi** correspond very closely in structure with the trachea; the cartilaginous rings are deficient behind, as in that tube; there are usually six to eight rings in the right bronchus and ten to twelve in the left.

THYROID GLAND.

The thyroid gland or body is a **blood-vascular gland**; in other words, it secretes into the numerous cavities of which it is composed a peculiar fluid, which, originally separated from the blood, is again taken up by the veins or lymphatic vessels or both, and conveyed into the circulation, in this way performing some function in connection with the formation or renovation of the blood. It is situated on the trachea, and may therefore be considered in this place, although bearing no part in the function of respiration.

This gland consists of two lobes, which are placed one on each side of the trachea, and are connected with each other by means of an **isthmus**, which crosses its upper rings, usually the third and fourth; but in this respect there is some variety, a point necessary to be remembered in operations on the trachea. The lobes are somewhat conical in shape, being larger below than above, and the smaller end is continued upwards to the side of the thyroid cartilage. The isthmus is connected with the lower third of the two lobes, and often gives origin to a process of variable length and size, called the **pyramid** or third lobe. The pyramid is generally situated on the left side of the isthmus and is sometimes derived from the left lobe. The left lobe is somewhat smaller than the right, the weight of the entire gland being about one ounce and a half. It is, however, larger in young persons and females than in adult males, and undergoes a slight increase during menstruation. Its permanent enlargement constitutes bronchocele, goître, or the Derbyshire neck.

Structure.—The structure of the thyroid is of a brownish-red colour, and is composed of a dense aggregation of minute and independent membranous cavities or vesicles enclosed by a plexus of capillary vessels, and connected together by areolar tissue. The vesicles are composed of a *basement membrane* lined by a *tesselated epithelium* of nucleated cells, and contain a clear yellowish fluid, in which are found cells; the latter measuring $\frac{1}{1400}$ of an inch in diameter.

A muscle is occasionally found connected with its isthmus, or with the pyramid, and is attached superiorly to the body of the os hyoides, or to the thyroid cartilage. It was named by Soemmering, "*levator glandulæ thyroideæ;*" fig. 363.

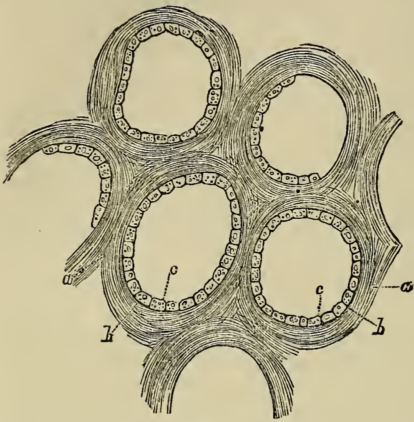


Fig. 368.—Structure of the thyroid gland. *a.* Connective-tissue stroma. *b.* Basement membrane. *c.* Epithelial cells.

Vessels and Nerves.—It is abundantly supplied with blood by the superior and inferior thyroid arteries. Sometimes an additional artery is derived from the arteria innominata, and ascends upon the front of the trachea to be distributed to the gland. The wounding of the latter vessel in tracheotomy might be fatal to the patient. The *nerves* are derived from the superior laryngeal and from the middle and inferior cervical ganglia of the sympathetic. The *lymphatics* are very numerous, and originate for the most part in the connective tissue forming the stroma of the organ.

THE LUNGS.

The lungs are two conical organs, situated one at each side of the chest, embracing the heart, and separated from each other by that organ and by an interspace, the mediastinum. On the external or thoracic side they are convex, and correspond with the form of the cavity of the chest; internally they are concave, to receive the convexity of the heart. Superiorly they terminate in a tapering cone, which extends above the level of the first rib into the root of the neck, and inferiorly they are broad and concave, and rest on the convex surface of the diaphragm. Their posterior border is rounded, broad, and long; the anterior, sharp, short, and marked by one or two deep fissures; and the inferior border which surrounds the base is also sharp. The colour of the lungs is pinkish-grey, mottled, and variously marked with black. The surface is figured with irregularly polyhedral outlines, which represent the lobules of the organ, and the area of each of these polyhedral spaces is crossed by lighter lines representing smaller lobules. The weight of the lungs is about forty ounces, the right lung being two ounces heavier than the left; the ratio to the weight of the body varies from 1 to 35 to 1 to 50.

Each lung is divided into two lobes by a long and deep fissure,

which extends from the posterior surface of the upper part of the organ downwards, and forwards to near the anterior angle of its base. In the right lung the upper lobe is subdivided by a second fissure, which extends obliquely forward from the middle of the preceding to the anterior border of the organ, and marks off a small triangular lobe. The left lung presents a deep notch in its anterior border, at a point corresponding with the apex of the heart.

The right lung is larger than the left, in consequence of the inclination of the heart to the left side. It is also shorter, from the great convexity of the liver, which presses the diaphragm upwards on the right side of the chest considerably above the level of the left, and it has three lobes. The left lung is smaller, has only two lobes, but is longer than the right.

Each lung is retained in its place by its **root**, which is formed by the pulmonary artery, pulmonary veins, and bronchial tubes, together with the bronchial vessels and pulmonary plexuses of nerves. The groove on the surface of the lung where the vessels enter its substance is the **hilum pulmonis**, and the position of the large vessels in the root of the lung, as follows: from before, backwards, they are placed in a similar order on both sides, viz. :—

Pulmonary veins,
Pulmonary artery,
Bronchus.

From above, downwards, on the **right** side, this order is exactly reversed; but on the **left** side, the bronchus has to stoop beneath the arch of the aorta, which alters its position to the vessels. They are thus disposed on the two sides :—

$$\textbf{Right,}\begin{cases}\text{Bronchus,}\\ \text{Artery,}\\ \text{Veins.}\end{cases}\qquad \textbf{Left,}\begin{cases}\text{Artery,}\\ \text{Bronchus,}\\ \text{Veins.}\end{cases}$$

The special relations of the roots of the lung are—for the right, the descending cava, which lies in front, and the vena azygos major, which arches over it from behind to terminate in the superior vena cava. The root of the left lung has the descending aorta lying behind it. The phrenic nerve lies in front of the root of each lung, and the pneumogastric behind; the ligamentum latum pulmonis extends from the under surface of each root to the upper surface of the diaphragm.

Structure.—The lungs are composed of the ramifications of the bronchial tubes (*bronchia*), which terminate in intercellular passages and air-cells, of the ramifications of the pulmonary arteries and veins, bronchial arteries and veins, lymphatics, and nerves; the whole of these structures, being held together by areolar tissue, constitute the *parenchyma.* When examined on the surface the lung is seen to consist of small polyhedral divisions, or lobules, which are connected to each other by an inter-lobular areolar tissue. These

lobules again consist of smaller lobules, and the latter are formed by a cluster of air-cells, in the parietes of which the capillaries of the pulmonary artery and pulmonary veins are distributed. Each lobule, taken alone, is provided with its separate bronchial tube, pulmonary artery, and vein, and is isolated from surrounding lobules by a process of areolar membrane derived from the subserous tissue; the entire lung is an assemblage of these lobules, so separated and so connected, held together by the pleura.

The serous investing membrane of the lungs or pleura is connected with the surface of the lobules by means of a *subserous areolar tissue*, which forms a distinct layer, and being prolonged between the lobules, is the bond of adhesion between them. This layer

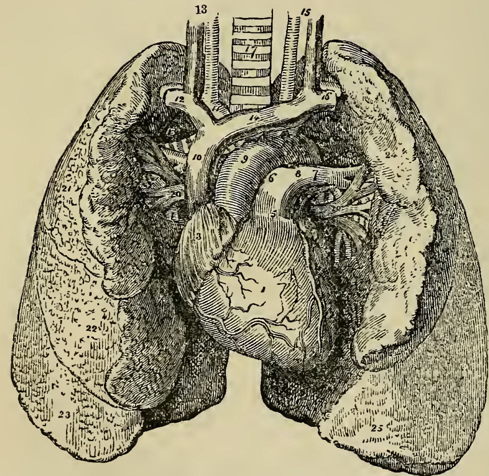


Fig. 369.—Heart and lungs. 1. Right ventricle, the vessels to the left of the figure are the right coronary artery and veins; those to its right, the left coronary artery and veins. 2. Left ventricle. 3. Right auricle. 4. Left auricle. 5. Pulmonary artery. 6. Right pulmonary artery. 7. Left pulmonary artery. 8. Ligament of the ductus arteriosus. 9. Arch of the aorta. 10. Superior vena cava. 11. Arteria innominata, and in front of it the right vena innominata. 12. Right subclavian vein, and, behind it, its corresponding artery. 13. Right common carotid artery and vein. 14. Left vena innominata. 15. Left carotid artery and vein. 16. Left subclavian vein and artery. 17. Trachea. 18. Right bronchus. 19. Left bronchus. 20, 20. Pulmonary veins; 18, 20, form the root of the right lung; and 7, 19, 20, the root of the left. 21. Superior lobe of the right lung. 22. Middle lobe. 23. Inferior lobe. 24. Superior lobe of the left lung. 25. Inferior lobe.

contains elastic tissue, and is a chief source of the elasticity of the lungs; in it a close plexus of capillary vessels is found.

Bronchial Tubes.—The two bronchi proceed from the bifurcation of the trachea opposite the third dorsal vertebra to their corresponding lungs. The right, about an inch long, takes its course nearly at right angles with the trachea, and enters the upper part of the right lung; while the left, two inches in length, and smaller than the right, passes obliquely beneath the arch of the aorta, and enters the lung at about the middle of its root. Upon entering the lungs they divide into two branches, and each of these divides and subdivides

dichotomously to their ultimate termination in the intercellular passages and air-cells.

The bronchial tubes continue to diminish in size until they attain a diameter of $\frac{1}{50}$ to $\frac{1}{30}$ of an inch, and arrive within $\frac{1}{8}$ of an inch of the surface of the lung. They then become changed in structure, and are continued onwards in the midst of air-cells, under the name of **intercellular passages.** Lastly, the intercellular passages, after several bifurcations, terminate each by a cæcal extremity or air-cell. The intercellular passages are at first cylindrical, like the bronchial tubes, but soon become irregular in shape from the great number of air-cells which open into them on all sides. The **air-cells** or **alveoli** in the adult lung measure between $\frac{1}{200}$ and $\frac{1}{70}$ of an inch; they are irregular in shape, and, most frequently, four-sided cavities, separated by thin septa, and communicating freely with the intercellular passages, and sparingly with the bronchial tubes.

In structure the bronchial tubes are composed of cartilages, fibrous membrane, muscular fibres, elastic fibres, and mucous membrane. The **cartilages** in the primary bronchi are six or eight in number in the right bronchus, and ten or twelve in the left. In the subsequent divisions of the bronchial tubes, which are cylindrical in figure, the cartilages assume the form of thin plates of irregular shape and size, adapted to each other by their edges, and completely surrounding the tubes. The plates are most strongly developed around the bifurcations of the tubes, and the point of division is furnished with a cartilage of a semilunar form. They are found entering into the structure of the bronchial tubes until the latter are reduced to a quarter of a line in diameter, and are then lost.

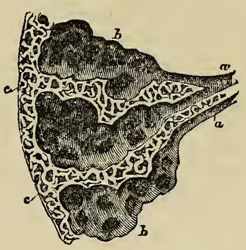


FIG. 370.—A diagram showing the dilatation of the ultimate bronchial tubes into intercellular passages, and the enlargement of the latter near the surface of the lung. *a, a.* Bronchial tubes. *b, b.* Intercellular passages, on the walls of which are seen opening the air-cells. *c, c.* Air-cells near the surface of the lung.

The **fibrous membrane**, which enters largely into the formation of the trachea and bronchial tubes, is the principal coat of the smallest tubes, and is continued to their terminations in the intercellular passages and air-cells.

The **muscular fibres** belong to the class of non-striated, organic muscle; they are arranged in rings around the tube, and form a muscular coat which is placed externally to the cartilaginous plates and is continued as far as the extremity of the tubes, being absent in the intercellular passages and air-cells. The **elastic fibres**, arranged in longitudinal fasciculi, form a thin stratum next the mucous lining; this elastic coat is prolonged to the ends of the tubes, and scattered fibres are found around the intercellular passages and air-cells. The **mucous membrane**, lining the bronchial tubes, is provided with a ciliated columnar epithelium as far as their termination; but in the inter-

cellular passages and air-cells it is altered in its characters, is thin and transparent, and coated with a squamous epithelium.

The **capillaries of the lungs** form plexuses which occupy the walls and septa of the air-cells and the walls of the intercellular passages, but are not continued into the bronchial tubes. The septa between the air-cells consist of a single layer of the capillary plexus enclosed in a fold of the mucous lining membrane. The air-cells of the central part of the lung are most vascular, and at the same time smallest, whilst those of the periphery are less vascular and larger.

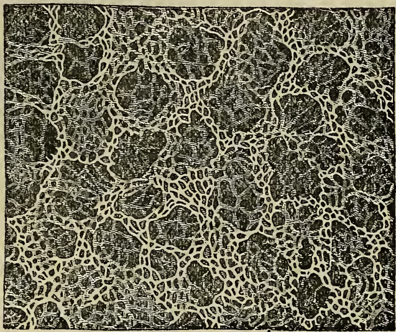


FIG. 371. — Arrangement of the capillaries of the human lung.

The pigmentary matter of the lungs is contained in the walls of the air-cells, as well as in the areolar tissue of the inter-lobular spaces and blood-vessels; it is composed chiefly of carbon.

The **pulmonary artery**, conveying the dark and impure venous blood to the lungs, terminates in capillary vessels, which form a dense network in the parietes of the intercellular passages and air-cells, and then converge to form the pulmonary veins, by which the arterial blood, purified in its passage through the capillaries, is returned to the left auricle of the heart.

The **bronchial arteries**, branches of the thoracic aorta, ramify on the parietes of the bronchial tubes, and terminate partly in bronchial veins which convey the venous blood to the vena azygos on the right side, and superior intercostal vein on the left; and partly in the pulmonary capillaries.

The **lymphatics**, commencing on the surface and in the substance of the lungs, terminate in the bronchial glands. These glands, very numerous and often of large size, are placed at the roots of the lungs, around the bronchi, and at the bifurcation of the trachea. In early life they resemble lymphatic glands in other situations; but in old age, and often in the adult, are black, and filled with carbonaceous matter, and occasionally with calcareous deposits.

The **nerves** are derived from the pneumogastric and sympathetic. They form two plexuses: **anterior pulmonary plexus**, situated upon the front of the root of the lungs, and composed chiefly of filaments from the deep cardiac plexus; and **posterior pulmonary plexus,** on the posterior aspect of the root of the lungs, composed principally of branches from the pneumogastric. The branches from these plexuses follow the course of the bronchial tubes, and are distributed to the intercellular passages and air-cells.

PLEURÆ.

Each lung is enclosed and its structure maintained by a serous membrane, the pleura, which invests it as far as the root, and is then reflected on the parietes of the chest. That portion of the membrane which is in relation with the lung is called *pleura pulmonalis*, and that in contact with the parietes, *pleura costalis*. The reflected portion, besides forming the internal lining to the ribs and intercostal muscles, also covers the diaphragm and thoracic surface of the vessels at the root of the neck, extending for somewhat more than an inch above the margin of the first rib. At the lower border of the root of the lung is a fold of the pleura, which extends down by the side of the posterior mediastinum to the diaphragm, and serves to retain the lower part of the lung in position. This fold is the broad ligament of the lung, *ligamentum latum pulmonis.*

On its external surface, where the pleura is connected with surrounding parts, it is rough; on its inner surface, smooth. At the right side, where the diaphragm is pressed upwards by the liver, the cavity of the pleura is shorter than on the left, but it extends higher into the neck; while the left pleural cavity, in consequence of the encroachment of the heart on the left side of the chest, is narrower than the right.

MEDIASTINUM.

The approximation of the two reflected pleuræ in the middle line of the thorax forms a septum, which divides the chest into the two pulmonary cavities. This is the mediastinum. The two pleuræ are not, however, in contact with each other at the middle line in the formation of the mediastinum, but have a space between them which contains all the viscera of the chest with the exception of the lungs. The mediastinum is divided into an *anterior*, *middle*, and *posterior* portion.

The **anterior mediastinum** is a triangular space, bounded *in front* by the sternum, triangularis sterni, sterno-hyoid, and sterno-thyroid muscles; *behind* by the pericardium and the remains of the thymus gland, and *at each side* by the pleura. It contains a quantity of loose areolar tissue, in which are found some lymphatic vessels passing upwards from the liver.

The **middle mediastinum** contains the heart enclosed in its pericardium, the ascending aorta, superior vena cava, pulmonary arteries and veins, bifurcation of the trachea, and phrenic nerves. With the exception of the trachea and phrenic nerves, the whole of the contents of this space lies within the pericardium.

The **posterior mediastinum** is bounded behind by the vertebral column, in front by the pericardium, and at each side by the pleura. It contains the thoracic aorta, the greater and lesser azygos veins, and superior intercostal veins, the thoracic duct, œsophagus, and

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pneumogastric nerves, the great splanchnic nerves, and some lymphatic glands.

A **superior mediastinum** is sometimes described. It is the part of the interpleural space which lies above the pericardium, and is bounded *in front* by the sternum, and the origin of the sterno-hyoid and sterno-thyroid muscles, *behind* by the vertebral column, and *on each side* by the pleura. It contains the remains of the thymus

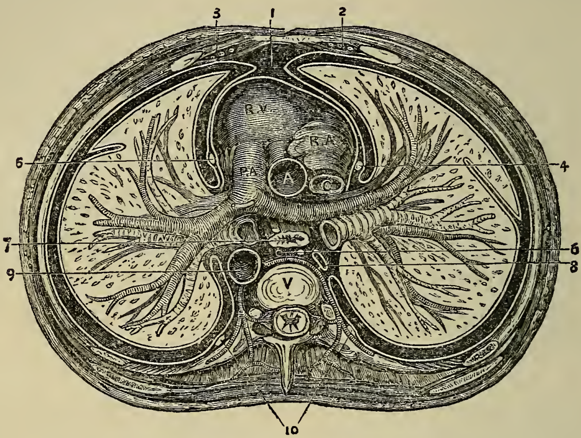

FIG. 372.—Transverse section of the thorax. 1. Anterior mediastinum. 2. Internal mammary vessels. 3. Triangularis sterni muscle. 4. Right phrenic nerve. 5. Left phrenic nerve. 6. Thoracic duct in posterior mediastinum. 7. Œsophagus with left vagus in front and right behind. 8. Vena azygos major. 9. Thoracic aorta giving off intercostal branches. 10. Gangliated cord of sympathetic. R.V. Right ventricle. R.A. Right auricle. P.A. Pulmonary artery. A. Aorta. C. Vena cava superior. V. Dorsal vertebra.

gland, the pneumogastric, cardiac, phrenic, and left recurrent laryngeal nerves; the trachea, œsophagus, and thoracic duct; the transverse portion of the arch of the aorta, and its three great branches; the two innominate veins, commencement of the superior vena cava, and termination of the vena azygos major.

THYMUS GLAND.

Although not directly connected with the organs of respiration, it is convenient to describe the thymus gland in this place, occupying, as it does, the anterior mediastinum, and lying in relation with the pleuræ and pericardium. The thymus is a temporary organ, which is of large size in the young child, but in the adult is reduced so as to become a mere vestige.

In its mature state it consists of a thoracic and a cervical portion

on each side. The former is situated in the anterior mediastinum, and the latter is placed in the neck just above the first bone of the sternum and behind the sterno-hyoid and sterno-thyroid muscles. It extends upwards from the fourth rib as high as the thyroid gland, resting against the pericardium, separated from the arch of the aorta and great vessels by fascia, and lying at each side of the trachea in the neck.

Although described usually as a single gland, it consists actually of two lateral, almost symmetrical glands, connected with each other by areolar tissue only, and having no structural communication; they may therefore be properly called a right and left thymus gland.

The thymus is perceptible as early as the seventh week of embryonic existence, and continues gradually increasing with the growth of the fœtus until the seventh month. At the eighth month it is large; during the ninth it undergoes a sudden change, assumes a greatly increased size, and at birth weighs 240 grains. After birth it continues to enlarge until the expiration of the second year, when it ceases to grow, and begins to diminish between the eighth and twelfth year, being often well developed at the age of twenty, and only disappearing entirely before forty.

The thymus is a ductless or blood-vascular gland, composed of lobules disposed in a spiral form around a central axis. The lobules are held together by a firm areolar tissue, and the entire gland is enclosed in a coarse areolar capsule.

The **lobules**, somewhat more than a quarter of an inch in diameter, of a rounded and pyriform shape, are composed of smaller lobules, and the *smaller lobules* are made up of small round or polygonal solid masses, the **gland nodules** or **follicles.** These are in every respect similar in structure to the lymphoid masses found in other parts of the body, as, for instance, in the tonsils, and the solitary and agminate glands of the intestine. They consist of retiform tissue, the meshes of which are crowded with lymph corpuscles; at the circumference of each nodule the retiform tissue is closer so as to form a sort of capsule. Scattered throughout the retiform tissue are peculiar, highly refracting corpuscles, which present an appearance of concentric striation, and have been named the *concentric corpuscles of Hassall.*

The **arteries** of the thymus gland are derived from the internal mammary, superior thyroid, and inferior thyroid. The **veins** terminate in the left vena innominata, and some small branches in the thyroid veins. The **nerves** are minute, and derived chiefly, through the internal mammary plexus, from the superior thoracic ganglion of the sympathetic. Other branches reach the gland from the phrenic, pneumogastric, and descendens noni nerves.

The **lymphatics** accompany the blood-vessels in the interior of the gland, terminate in the general union of the lymphatic vessels at the junction of the internal jugular and subclavian vein.

ABDOMEN.

The abdomen is the inferior cavity of the trunk of the body; it is bounded *in front*, and *at the sides*, by the lower ribs and abdominal muscles; *behind*, by the vertebral column and abdominal muscles; *above*, by the diaphragm; and *below*, by the pelvis; and contains the alimentary canal, the organs subservient to digestion—viz., the liver, pancreas, and spleen; and the organs of excretion, the kidneys, with the supra-renal capsules.

Regions.—For convenience of description of the viscera, and of reference to the morbid affections of this cavity, the abdomen is divided into certain districts or regions. Thus, if two transverse lines be carried around the body, the one parallel with the cartilages of the eighth ribs, the other with the highest point of the crests of the ilia, the abdomen will be divided into three zones. Again, if a perpendicular line be drawn, at each side, from the cartilage of the eighth rib to the middle of Poupart's ligament, the three primary zones will each be subdivided into three compartments or regions, middle and two lateral.

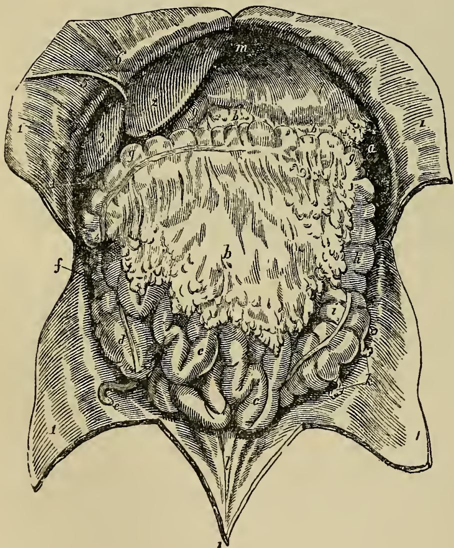

FIG. 373.—Viscera of the abdomen *in situ*. 1, 1. Flaps of the abdominal parietes turned aside. 2. Liver, its left lobe. 3. Right lobe. 4. Fundus of the gall-bladder. 5. Round ligament of the liver, issuing from the cleft of the longitudinal fissure, and passing along the parietes of the abdomen to the umbilicus. 6. Part of the broad ligament of the liver. 7. Stomach. 8. Its pyloric end. 9. Commencement of the duodenum. *a*. Lower extremity of spleen. *b*, *b*. Greater omentum. *c*, *c*. Small intestines. *d*. Cæcum. *e*. Vermiform appendix. *f*. Ascending colon. *g*, *g*. Transverse colon. *h*. Descending colon. *i*. Sigmoid flexure of colon. *k*. Appendices epiploicæ connected with the sigmoid flexure. *l*. Three ridges representing the cords of the urachus and hypogastric arteries ascending to the umbilicus. *m*. Diaphragm.

The middle region of the upper zone being immediately over the

small end of the stomach, is called **epigastric** (ἐπὶ γαστὴρ, over the stomach). The two lateral regions being under the cartilages of the ribs, are called right and left **hypochondriac** (ὑπὸ χόνδροι, under the cartilages). The middle region of the middle zone is the **umbilical**; the two lateral, the **lumbar.** The middle region of the inferior zone is the **hypogastric** (ὑπὸ γαστὴρ, below the stomach); and the two lateral, the **iliac.** In addition to these divisions, we employ the term **inguinal region,** in reference to the vicinity of Poupart's ligament.

Position of the Viscera.—The position of the viscera which occupy these several regions may be best understood and remembered, by arranging them in a tabular form, as follows:—

Right Hypochondriac.	Epigastric.	Left Hypochondriac.
Right lobe of liver, Gall bladder, Ascending duodenum, Hepatic flexure of colon, Upper end of kidney, Supra-renal capsule.	Pyloric end of stomach. Pancreas, Left lobe of liver.	Great end of stomach, Spleen, Tail of pancreas, Splenic flexure of colon, Upper end of kidney, Supra-renal capsule.
Right Lumbar.	**Umbilical.**	**Left Lumbar.**
Ascending colon, Lower part of kidney, Descending duodenum, Jejunum.	Great omentum, Mesentery. Transverse colon, Transverse duodenum, Small intestines.	Descending colon, Lower part of kidney, Jejunum.
Right Iliac.	**Hypogastric.**	**Left Iliac.**
Cæcum, Vermiform appendix, Ilium, Ureter.	Ilium, (Bladder and uterus when enlarged.)	Sigmoid flexure, Ureter.

PERITONEUM.

The *peritoneum* (περιτείνειν, to extend around) forms a completely shut sac, excepting in the female, where the peritoneum is perforated by the open extremities of the Fallopian tubes, and is continuous with their mucous lining.

The simplest idea that can be given of a serous membrane is, that it invests the viscus or viscera, and is then reflected on the parietes of the containing cavity. If the cavity contain only a single viscus, the consideration of the serous membrane is extremely simple. But in the abdomen, where there are a number of viscera, the serous membrane passes from one to the other until it has invested the whole, before it is reflected on the parietes. Hence its reflections are a little more complicated.

In tracing the reflections of the peritoneum, in the middle line,

we commence with the diaphragm, which is lined by two layers, one from the parietes in front, *anterior*, and one from the parietes behind, *posterior*. These two layers of the same membrane, at the posterior part of the diaphragm, descend to the upper surface of the liver, forming the **coronary** and **lateral ligaments** of the liver. They then surround the liver, one going in front, the other behind that viscus, and meeting at its under surface, pass to the stomach, forming the **lesser omentum.** They then, in the same manner,

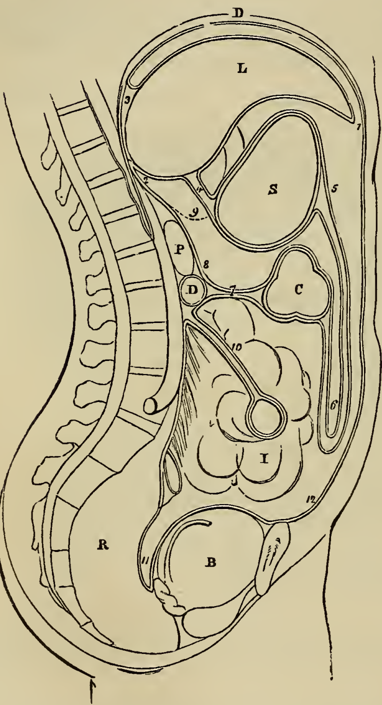

FIG. 374.—Reflections of the peritoneum. D. Diaphragm. L. Liver. S. Stomach. C. Transverse colon. D. Transverse duodenum. P. Pancreas. I. Small intestines. R. Rectum. B. Urinary bladder. 1. Anterior layer of peritoneum, lining the under surface of the diaphragm. 2. Posterior layer. 3. Coronary ligament, formed by the passage of these two layers to the posterior border of the liver. 4. Lesser omentum; the two layers passing from the under surface of the liver to the lesser curve of the stomach. 5. The two layers meeting at the greater curve, then passing downwards and returning upon themselves, forming (6) the greater omentum. 7. Transverse meso-colon. 8. Posterior layer traced upwards in front of D, transverse duodenum, and P, pancreas, to become continuous with the posterior layer (2). 9. Foramen of Winslow; the dotted line bounding this foramen inferiorly marks the course of the hepatic artery forwards, to enter between the layers of the lesser omentum. 10. Mesentery encircling the small intestines. 11. Recto-vesical fold, formed by the descending anterior layer. 12. Anterior layer traced upwards on the inner surface of the abdominal parietes to the layer (1), with which the examination commenced.

surround the stomach, and meeting at its lower border, descend for some distance in front of the intestines, and return to the transverse colon, forming the **great omentum**; they then surround the transverse colon, and pass directly backwards to the vertebral column, forming the transverse **meso-colon.** Here the two layers separate; the *posterior* ascends in front of the pancreas and aorta, and returns to the posterior part of the diaphragm, where it becomes the posterior layer with which we commenced. The *anterior* descends, invests

all the small intestines, and returning to the vertebral column, forms the **mesentery.** It then descends into the pelvis in front of the rectum, which it holds in its place by means of a fold called **meso-rectum,** forms a pouch, the **recto-vesical fold,** between the rectum and the bladder, ascends upon the posterior surface of the bladder, forming its false ligaments, and returns upon the anterior parietes of the abdomen to the diaphragm, whence we first traced it.

In the female, after descending into the pelvis in front of the rectum, it is reflected upon the posterior surface of the vagina and uterus. It then descends on the anterior surface of the uterus, and forms at either side the broad ligaments of that organ. From the uterus it ascends upon the posterior surface of the bladder, and anterior parietes of the abdomen, and is continued, as in the male, to the diaphragm.

In like manner the peritoneum can be traced as a continuous sheet from one side to the other side of the abdomen. Thus, if we commence at the middle line in front and follow it across the abdomen below the level of the transverse colon, we shall find that it passes from the abdominal wall to the right iliac fossa where it covers in the cæcum and ascending colon, forming the meso-cæcum and ascending meso-colon; it then passes inwards and forms the mesentery which attaches the small intestines to the vertebral column, and may be traced from thence to the left iliac fossa where it covers the sigmoid flexure (sigmoid meso-colon); it is then continued on to the abdominal wall, terminating at the point whence we set out. Above the transverse colon the arrangement is more complicated, in consequence of the existence of two cavities, a greater and a lesser. Beginning at the middle line we may trace the peritoneum over the right kidney into the right hypochondrium; it then passes across the body in front of the pancreas, and returns from left to right along the posterior surface of the stomach, so as to reach the **foramen of Winslow,** where it forms the posterior layer of the

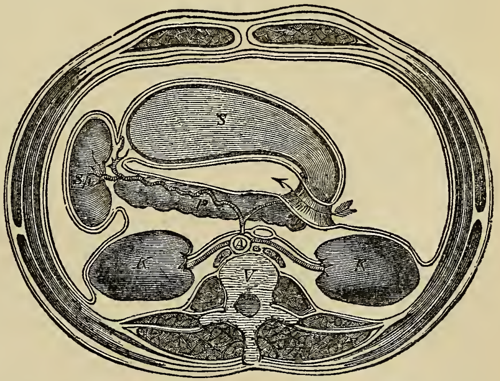

FIG. 375.—Transverse section of the abdomen at the level of the foramen of Winslow. The arrow passes from the greater to the lesser cavity of the peritoneum through the foramen of Winslow which is shown in section. S. Stomach. P. Pancreas. Sp. Spleen. K. Kidney. V. Vertebra. A. Aorta.

lesser omentum. It now becomes reflected on itself round the structures (hepatic artery, portal vein, and common bile duct) forming the pillar of the foramen of Winslow, and constitutes the anterior layer of the lesser omentum. Passing over the anterior surface of the stomach, it is continued on the spleen, which it encloses (forming the **gastro-splenic omentum**), and so passes to the left hypochondrium, and from thence to the anterior wall of the abdomen.

The viscera, which are thus shown to be invested by the peritoneum in its course from above downwards, are the—

Liver, Transverse colon,
Stomach, Small intestines,
Pelvic viscera.

The folds formed between these and between the diaphragm and the liver are—

(Diaphragm.)

Broad, coronary, and lateral ligaments.

(Liver.)

Lesser omentum.

(Stomach.)

Great omentum.

(Transverse colon.)

Transverse meso-colon.

Mesentery,

Meso-rectum,

Recto-vesical fold,

False ligaments of the bladder.

And in the female, the—

Broad ligaments of the uterus.

The ligaments of the liver will be described with that organ.

The **lesser omentum** (gastro-hepatic) is the duplicature which passes between the liver and the upper border of the stomach. It is extremely thin, excepting at its right border, where it is free, and contains between its layers the—

Hepatic artery, Portal vein,
Ductus communis choledochus, Lymphatics,
Hepatic plexus of nerves.

These structures are enclosed in a loose areolar tissue called *Glisson's capsule.* The relative position of the three vessels is, the artery to the left, the duct to the right, the vein between and behind.

If the finger be introduced behind this right border of the lesser omentum, it will be situated in an opening called the **foramen of**

Winslow. In *front* of the finger will lie the right border of the lesser omentum, containing the hepatic artery, portal vein, and hepatic duct; *behind* it, the right crus of the diaphragm and inferior vena cava covered by the ascending or posterior layer of the peritoneum; *below*, the hepatic artery, curving forward from the cœliac axis, and the ascending portion of the duodenum; and *above*, the lobus Spigelii. These, therefore, are the *boundaries of the foramen of Winslow*, which is nothing more than a constriction of the general cavity of the peritoneum at this point, arising out of the necessity for the hepatic and gastric arteries to pass forwards from the cœliac axis to reach their respective viscera.

If air be blown through the foramen of Winslow, it will descend behind the lesser omentum and stomach to the space between the descending and ascending pair of layers, forming the great omentum. This is sometimes called the lesser cavity of the peritoneum, and that external to the foramen the greater cavity; in which case the foramen is considered as the means of communication between the two. It may be objected to this division that it tends to lead the inexperienced to believe that there are two cavities, while, in reality, there is but one, the foramen of Winslow being merely a constriction of that one, to facilitate the communication between the nutrient arteries and the viscera of the upper part of the abdomen.

The **great omentum** (gastro-colic) consists of *four layers of peritoneum*, the two which descend from the stomach, and the same two, returning upon themselves to the transverse colon. A quantity of adipose substance is deposited around the vessels which ramify through its structure. It would appear to perform a double function in the economy, namely, protecting the intestines from cold, and, facilitating the movement of the intestines on each other during their vermicular action. In the fœtus and young child, and occasionally in the adult, it is possible to separate the ascending layers of the great omentum from the transverse colon, and to trace them to the vertebral column on the upper surface of the transverse meso-colon, with which, however, they are only loosely connected. Under these circumstances the latter fold is formed by a separate duplicature of the peritoneum, and is not the direct continuation of the omentum, as in the description above given.

The **transverse meso-colon** (*μέσος*, middle, being attached to the middle of the cylinder of the intestine) is the medium of connection between the transverse colon and the posterior wall of the abdomen. It affords to the nutrient arteries a passage to reach the intestine, and also forms a transverse septum across the abdominal cavity. On reaching the posterior wall of the abdomen, its two layers separate from each other on the anterior aspect of the transverse duodenum, the one ascending to cover in the pancreas, kidneys, and supra-renal capsules, and to pass from thence to the under surface of the diaphragm, the other descending to form the mesentery, and then passing into the pelvis.

The **mesentery** (μέσον ἔντερον, connected to the middle of the cylinder of the small intestine) is the medium of connection between the small intestines and the posterior wall of the abdomen. It is oblique in direction, being attached to the posterior wall, from the left side of the second lumbar vertebra to the right iliac fossa; retains the small intestines in their place, and contains between its folds the mesenteric arteries, veins, nerves, lymphatic glands, and lacteal vessels.

The **meso-rectum**, in like manner, retains the rectum in connection with the front of the sacrum. Besides this, there are some minor folds in the pelvis, as the **recto-vesical** fold, the **false ligaments of the bladder**, and the **broad ligaments of the uterus.**

The **appendices epiploicæ** are small irregular pouches of the peritoneum, filled with fat, and attached like fringes to the colon, and upper part of the rectum.

Three other duplicatures of the peritoneum are situated in the sides of the abdomen; they are the gastro-phrenic ligament, the gastro-splenic omentum, the ascending and descending meso-colon, and the costo-colic ligament. The **gastro-phrenic ligament** is a small duplicature of the peritoneum, which descends from the diaphragm to the extremity of the œsophagus, and lesser curve of the stomach. The **gastro-splenic omentum** (ligamentum gastro-lienale) is the duplicature which connects the spleen to the stomach. The **ascending meso-colon** is the fold which connects the upper part of the ascending colon with the posterior wall of the abdomen; and the **descending meso-colon**, that which retains the sigmoid flexure in connection with the abdominal wall. The **costo-colic ligament** (sustentaculum lienis) is a fold of peritoneum which stretches from the diaphragm about the level of the tenth or eleventh rib on the left side, to the splenic flexure of the colon; it supports the spleen.

ALIMENTARY CANAL.

The alimentary canal is a musculo-membranous tube, extending from the mouth to the anus. It is variously named in the different parts of its course, and is divided into the—

Mouth,
Pharynx,
Œsophagus,
Stomach,

Small intestine { Duodenum, Jejunum, Ileum,

Large intestine { Cæcum, Colon, Rectum.

The **mouth** (cavitas oris) is the irregular cavity which contains the organ of taste and the principal instruments of mastication. It is bounded *in front* by the lips, on either *side* by the internal surface of the cheeks; *above*, by the hard palate and teeth of the

upper jaw; *below*, by the tongue, the mucous membrane stretched between the arch of the lower jaw and the under surface of the tongue, and by the teeth of the inferior maxilla; and *behind* by the soft palate and fauces. The space between the teeth and fleshy walls of the face is the *vestibulus oris.*

The **lips** (labium superius et inferius) are two fleshy folds formed externally by common integument and internally by mucous membrane, and containing between these two layers, muscles, a quantity of fat, and numerous small *labial glands.* They are attached to the surface of the upper and lower jaw, and each lip is connected to the gum in the middle line by a fold of mucous membrane, the *frænum labii superioris* and *frænum labii inferioris*, the latter being very small.

The **cheeks** (buccæ) are continuous with the lips, and form the sides of the face; they are composed of integument, a large quantity of fat, muscles, mucous membrane, and *buccal glands.*

The mucous membrane lining the cheeks is reflected above and below on the sides of the jaws, and is attached posteriorly to the anterior margin of the ramus of the lower jaw. At about its middle, opposite the second molar tooth of the upper jaw, is a papilla, on which may be observed a small opening, the aperture of the duct of the parotid gland (Stenson's duct).

The **hard palate** (palatum durum, seu, osteum) is a dense structure, composed of mucous membrane, *palatine glands*, areolar tissue, vessels, and nerves, and firmly connected to the palate processes of the superior maxillary and palate bones. It is bounded in front and at each side by the alveolar processes and gums, and is continuous behind with the soft palate. Along the middle line it is marked by an elevated raphé, and presents at each side of the raphé a number of transverse ridges and grooves. Near its anterior extremity, and immediately behind the middle incisor teeth, is a papilla which corresponds with the termination of the anterior palatine canal, and receives the naso-palatine nerves.

The **gums** (gingivæ) are composed of a thick and dense mucous membrane, which is closely adherent to the periosteum of the alveolar processes, and embraces the necks of the teeth. They are remarkable for their hardness and insensibility, and for their close contact, without adhesion, to the surface of the tooth. From the neck of the tooth they are reflected into the alveolus and become continuous with the periosteal membrane of that cavity (alveolo-dental membrane).

The **tongue** has been already described as an organ of sense; it is invested by mucous membrane, which is reflected from its under part upon the inner surface of the lower jaw, and constitutes with the muscles beneath the floor of the mouth. On the under surface of the tongue, near its anterior part, the mucous membrane forms a considerable fold, which is called the **frænum linguæ**, and on each side of the frænum is a large papilla, *caruncula sublingualis*, the termination of the duct (Wharton's duct) of the submaxillary

gland. Running back from this papilla is a ridge occasioned by the prominence of the sublingual gland, and opening along the summit of this ridge a number of small openings, the apertures of the excretory ducts (ducts of Rivinus) of the gland. Posteriorly the tongue is connected with the os hyoides by muscle, and to the epiglottis by three folds of mucous membrane, the **glosso-epiglottidean folds.**

The **soft palate** (palatum molle ; velum pendulum palati) is a

Fig. 376.—Median section of mouth, nose, pharynx, and larynx. *a.* Septum of nose ; below it, section of hard palate. *b.* Tongue. *c.* Section of velum pendulum palati. *d, d.* Lips. *u.* Uvula. *r.* Anterior pillar of fauces. *i.* Posterior pillar. *t.* Tonsil. *p.* Pharynx. *h.* Hyoid bone. *k.* Thyroid cartilage. *n.* Cricoid cartilage. *s.* Epiglottis. 1. Posterior opening of nares. 3. Isthmus faucium. 4. Upper opening of larynx. 5. Œsophagus. 6. Eustachian tube.

fold of mucous membrane situated at the posterior part of the mouth. It is continuous, superiorly, with the hard palate, and is composed of a double fold of mucous membrane, **palatine glands,** and muscles ; it is concave towards the mouth and convex towards the pharynx, and presents a free festooned edge inferiorly. The mucous membrane is continuous with that of the hard palate, but is thinner and darker, and is covered by stratified squamous epithe-

lium, excepting at the extreme upper part of its posterior surface, near the opening of the Eustachian tube, where it is columnar and ciliated. Hanging from the middle of its inferior border is a small rounded process, the **uvula**, and passing outwards from the uvula at each side are two curved folds of the mucous membrane, the arches or pillars of the palate. The **anterior pillar** is continued downwards to the side of the base of the tongue, and is formed by the prominence of the palato-glossus muscle. The **posterior pillar** is prolonged downwards and backwards into the pharynx, being formed by the convexity of the palato-pharyngeus muscle. These two pillars, closely united above, are separated below by a triangular interval or niche, in which the tonsil is lodged.

The space included between the soft palate and the root of the tongue is the **isthmus of the fauces.** It is bounded *above* by the soft palate, on each *side* by the pillars of the soft palate and tonsil, and *below* by the root of the tongue. It is the opening between the mouth and pharynx.

The **tonsils** (amygdalæ) are two glandular organs, about half an inch in length, shaped like almonds, and situated between the anterior and posterior pillar of the soft palate, at each side of the fauces. Externally, they are invested by the pharyngeal fascia, which separates them from the superior constrictor muscle and internal carotid artery, and prevents an abscess from opening in that direction; and correspond in position to the angle of the lower jaw, behind which they may be felt when enlarged. They present on their surface the openings of twelve to fifteen mucous crypts, similar to those at the root of the tongue and described below under the name of lingual glands. The substance of the tonsil is formed of retiform or lymphoid tissue.

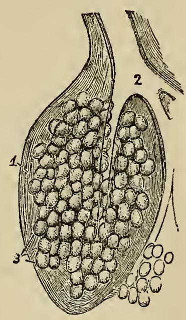

Fig. 377.—One lobe of a racemose mucous gland from the floor of the mouth. 1. Sheath of areolar tissue. 2. Excretory duct. 3. Glandular vesicles or acini.

The **mucous glands** of the mouth are racemose glands; they are yellowish or whitish in colour, rounded in form, and situated in the submucous areolar tissue. The **labial glands** vary in size from half a line to one line and a half in diameter, and form an almost continuous layer around the mouth. The **buccal glands** are numerous, but smaller than the labial; a few of larger size being located near the aperture of Stenson's duct. The **molar glands** are placed between the masseter and buccinator, and pierce the latter with their ducts opposite the molar teeth. The **palatine glands** are situated in the posterior half of the hard palate and in the soft palate; in the latter forming a layer several lines in breadth. They are also numerous but small on the posterior part of the soft palate. The **lingual glands** form a thick stratum in the submucous tissue beneath the mucous crypts at

the root of the tongue; the layer of glands extends completely across the tongue, and their ducts, several lines in length, open by infundibuliform expansions, some into the mucous crypts, others into the foramen cæcum, others into the fossæ of the papillæ circumvallatæ, and others between the papillæ. They are surrounded by a large quantity of lymphoid tissue which is here and there collected into round masses called lymphoid follicles, many of these being grouped around the cavities of the mucous crypts. Mucous glands are also dispersed on other parts of the tongue, but are smaller and few in number: a small group is found between the vertical folds on the sides of the tongue and a considerable group on its under surface near the tip and on either side of the frænum linguæ.

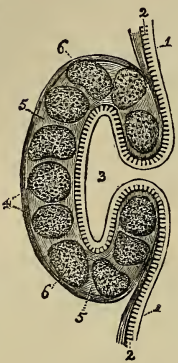

FIG. 378.—Mucous crypt from the root of the tongue. 1, 1. Epithelium. 2, 2. Papillæ of the mucous membrane. 3. Cavity of the crypt. 4. Investing coat of the gland, composed of areolar tissue. 5, 5. Fibro-vascular matrix, forming the parenchyma of the crypt; and containing, 6, 6, Lymphoid follicles surrounding the crypt.

SALIVARY GLANDS.

Communicating with the mouth are the excretory ducts of three pairs of salivary glands—the parotid, submaxillary, and sublingual.

The **PAROTID GLAND** (*παρὰ*, near; *οὖς*, *ὦτος*, the ear), the largest of the three, is situated immediately in front of the external ear, and extends superficially for a short distance over the masseter muscle; on its deep aspect it is projected inwards by two processes, one of which lies between the styloid and mastoid processes, and fills up the back part of the glenoid cavity, the other passes in front of the styloid process. It reaches inferiorly to below the level of the angle of the jaw, and posteriorly to the mastoid process, slightly overlapping the insertion of the sterno-mastoid muscle. It is separated from the submaxillary gland by the stylo-maxillary ligament. Embedded in its substance are—the external carotid artery, temporo-maxillary vein, and facial nerve; emerging from its anterior border, the transverse facial artery and branches of the facial nerve, and above, the temporal artery and auriculo-temporal nerve.

The **duct of the parotid gland (Stenson's duct)**, about two inches in length, and about the diameter of a crow's quill, issues from the anterior part of the gland, just below the zygoma, and crosses the masseter muscle; it then curves inwards over the anterior border of the muscle, and pierces the buccinator opposite the second molar tooth of the upper jaw; its course through the mucous membrane of the cheek is very oblique, so that the posterior border of its opening forms a valvular fold, which prevents fluid from pass-

ing from the mouth into the duct. The course taken by the duct may be roughly indicated by a line drawn from the bottom of the lobule of the ear to a point midway between the mouth and nose.

The duct is dense in structure, and its walls of considerable thickness in proportion to the area of the tube, which is remarkably small. A small glandular appendage, the *socia parotidis*, is connected with the upper part of the duct on the masseter muscle; and opens into it by one or several small ducts.

The **SUBMAXILLARY GLAND**, rounded in its form, is situated in the posterior part of the submaxillary triangle of the neck. It rests on the hyo-glossus, stylo-glossus, and mylo-hyoid muscles, and is covered in by the body of the lower jaw and the deep cervical fascia. It is separated from the parotid gland by the stylo-maxillary ligament, and from the sublingual gland by the mylo-hyoid muscle. Embedded among its lobules are the facial artery and submaxillary ganglion.

Its excretory duct, **Wharton's duct**, about two inches in length, issues from the middle of the gland, and passes between the mylo-hyoid and hyo-glossus to the frænum linguæ, by the side of which it terminates at the apex of a papilla, *caruncula sublingualis*. A process of the gland is prolonged with the duct for a short distance behind the mylo-hyoid.

The **SUBLINGUAL** is a long and flattened gland, situated beneath the mucous membrane of the floor of the mouth, at each side of the frænum linguæ. It is in relation at the frænum with its fellow of the opposite side, and in the rest of its course lies between the lower jaw and genio-hyo-glossus, being bounded below by the mylo-hyoid. It is in relation also with the duct of the submaxillary gland and the hypoglossal nerve.

Its secretion is poured into the mouth by from seven to twenty short ducts, **ducts of Rivinus**, which open on the ridge made by the gland in the floor of the mouth; the larger openings being situated by the side of the frænum linguæ. One of the ducts longer than the rest, and opening close to Wharton's duct, has been named *ductus Bartholini*.

Structure.—The salivary glands are of the racemose kind, consisting of lobes which are made up of polyhedral lobules; and these of smaller lobules; in minute structure they correspond with the racemose glands described on p. 54.

The submaxillary and sublingual glands are looser in structure and their lobules larger than those of the parotid gland.

The excretory ducts are thick and dense, composed of areolar and elastic tissue, and lined by a layer of *columnar epithelium*; and Wharton's duct is additionally provided with a longitudinal layer of smooth muscular fibre. The secretion of the salivary glands is a clear fluid, sometimes containing a small quantity of mucus and the detritus of epithelial cells.

Vessels and Nerves.—The parotid gland is abundantly supplied with *arteries* by the external carotid; the submaxillary by the facial

and lingual; and the sublingual by the sublingual and submental branches of the lingual artery. The capillaries form networks around and in contact with the glandular vesicles.

The **nerves** of the parotid gland are derived from the auriculo-temporal branch of the inferior maxillary, from the auricularis magnus, and from the nervi molles accompanying the external carotid artery. The submaxillary gland is supplied by the branches of the submaxillary ganglion, sympathetic, and filaments from the mylo-hyoid nerve; and the sublingual by filaments from the submaxillary ganglion and gustatory nerve. The relation of the nerves to the gland cells and cells of the ducts has been described with the structure of racemose glands (p. 55).

PHARYNX.

The pharynx (φάρυγξ, the throat) is a musculo-membranous sac, about four inches in length, situated on the cervical portion of the vertebral column, and extending from the base of the skull to a point corresponding with the cricoid cartilage in front and the fifth cervical vertebra behind. It is composed of mucous membrane, muscles, and a strong aponeurosis; and communicates in front with the cavity of the nose, mouth, and larynx. Above it is attached partly by muscle, but chiefly by aponeurosis, to the basilar process of the occipital bone and petrous portion of the temporal bone, and below it is continuous with the œsophagus. Its central attachment above is by means of a strong band having its origin from the pharyngeal tubercle on the occipital bone, and passing down between the recti antici muscles to terminate in the pharyngeal aponeurosis; this band has been termed by Cleland the *cranio-pharyngeal ligament.*

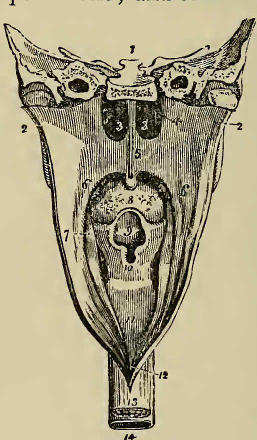

FIG. 379.—Pharynx laid open from behind. 1. Section carried transversely through the base of the skull. 2, 2. Walls of the pharynx drawn aside. 3, 3. Posterior nares, separated by the vomer. 4. Extremity of one Eustachian tube. 5. Soft palate. 6. Posterior pillar of the soft palate. 7. Anterior pillar; the tonsil is seen in the niche between the two pillars. 8. Root of the tongue, partly concealed by the uvula. 9. Epiglottis, overhanging (10) the cordiform opening of the larynx. 11. Posterior part of the larynx. 12. Opening of the œsophagus. 13. Œsophagus. 14. Trachea.

The **pharyngeal aponeurosis** is a strong sheet of fascia placed between the mucous membrane and muscles of the pharynx; it is strong and thick above, but thins as it passes downwards, and at the lower part of the pharynx is distinguishable only as a layer of diffuse areolar tissue.

The **mucous membrane** varies greatly in its character in different parts of the pharynx; it is thick where it clothes the base of the skull, but thinner in the neighbourhood of the Eustachian tube, and near the posterior nares; in the latter situations numerous racemose glands are seated in the submucous tissue, and pour their secretion on to the surface of the membrane. Lymphoid tissue is everywhere abundant, and at the back part of the pharynx forms a glandular mass stretching across between the openings of the two Eustachian tubes, which receives the name of the *pharyngeal tonsil.*

At its anterior part the pharynx has opening into it seven foramina, viz. :—

Posterior nares, two,	Larynx,
Eustachian tubes, two,	Œsophagus.
Mouth,	

The **posterior nares** are the two large openings at the upper and front part of the pharynx. On each side of these openings, and parallel with the posterior termination of the inferior turbinated bone, is the slit-like opening in the mucous membrane, marking the aperture of the **Eustachian tube.** Beneath the posterior nares is the isthmus faucium, the large opening into the **mouth**, partly veiled by the soft palate: and beneath the root of the tongue, the cordiform opening of the larynx. The **œsophageal** opening is the lower constricted portion of the pharynx.

ŒSOPHAGUS.

The œsophagus (*οἴειν*, to bear; *φάγειν*, to eat) is a slightly flexuous canal, inclining to the left in the neck, to the right in the upper part of the thorax, and again to the left in its course through the posterior mediastinum; it commences at the termination of the pharynx, opposite the lower border of the cricoid cartilage and fifth cervical vertebra, and descends the neck, behind and rather to the left of the trachea. It then passes behind the arch of the aorta and left bronchus, and along the posterior mediastinum, lying in front of the thoracic aorta; at the lower part of the thorax it lies slightly to the left of the aorta, and passing through the œsophageal opening in the diaphragm enters the abdomen, and terminates at the cardiac orifice of the stomach opposite the ninth or tenth dorsal vertebra. As it follows the curves of the vertebral column, it presents in its upper part an antero-posterior flexure. The œsophagus is flattened and narrow in the cervical region, and cylindrical in the rest of its course; its largest diameter being met with near the lower part; it is connected by loose areolar tissue to surrounding structures. In the relaxed condition its mucous membrane assumes the condition of longitudinal folds, which lie in contact with each other; when distended the folds disappear.

Structure.—The œsophagus is formed of three coats—an *outer*, muscular; a *middle*, submucous or areolar; and an *inner*, mucous.

The **muscular coat** consists in its upper part of striped fibres, but these gradually pass, about its middle, into the unstriped variety, and in its lower part the latter form only is found. The fibres are arranged in an outer *longitudinal*, and an inner *circular* layer; the *longitudinal fibres* are in the upper part of the tube disposed in three fasciculi, two lateral, which are continuous with those of the inferior constrictor, and one anterior which is attached to the vertical ridge of the cricoid cartilage. The *circular fibres* are attached superiorly to the cricoid cartilage; they are transverse in their arrangement, above and below, but spiral in the middle of the œsophagus. Below, both sets of fibres are continuous with those of the stomach. The **submucous coat** loosely connects the mucous and muscular coats; it is thicker than the latter, is composed of areolar tissue containing many elastic fibres, and has embedded in it the glands which open on to the surface of the mucous membrane. The **mucous membrane** is pale in colour but of firm texture. It is studded over with a number of very fine papillæ, and is covered by a stratified epithelium. A number of racemose glands situated in the submucous tissue, open by short ducts on to its surface. Between it and the submucous layer is a thin stratum of unstriped muscle, the fibres of which are for the most part longitudinally disposed, and have been named the *muscularis mucosæ.*

THE STOMACH.

The stomach is an expansion of the alimentary canal, situated in the left hypochondriac and epigastric region, and, for a small extent, in the right hypochondriac region. It is directed almost vertically from above downwards, but its pyloric extremity passes towards the right, and terminates in the right hypochondrium; fully three-fourths of it lies to the left of the middle line of the body. On account of the peculiarity of its form, it is divided into a middle part or *body*, a *greater* or *splenic*, and a *lesser* or *pyloric end;* a *lesser curvature* above, and a *greater curvature* below; an *anterior* and a *posterior surface;* a *cardiac orifice*, and a *pyloric orifice.* The great end (fundus) is not only of large size, but expands beyond the point of entrance of the œsophagus, and is embraced by the concave surface of the spleen; it presents superiorly a funnel-shaped expansion, leading to the cardiac orifice. The pylorus (janitor) is the small and contracted extremity of the organ; it is situated on a plane anterior and inferior to the cardiac orifice, and lies in contact with the under surface of the liver, often reaching to the gall-bladder. Near the lesser end is a dilatation, the *antrum of the pylorus.* The two curvatures give attachment to the peritoneum; the upper curve to the lesser omentum, the lower to the great omentum. The anterior surface looks upward and forward, and is in relation with the diaphragm (which separates it from the viscera of the thorax and six lower ribs), with the left lobe of the liver, and in the epigastric region with the abdominal parietes. The posterior

surface looks downwards and backwards, and is in relation with the diaphragm, pancreas, third portion of the duodenum, transverse meso-colon, left kidney, and left supra-renal capsule; this surface forms the anterior boundary of that cul-de-sac of the peritoneum which is situated behind the lesser omentum and extends into the great omentum. In a state of distension, as after a meal, the anterior surface becomes superior, and the greater curvature is directed forwards against the abdominal parietes. It is a little larger in the male than in the female, and in the former measures about twelve inches in length, and four or five inches in width at its

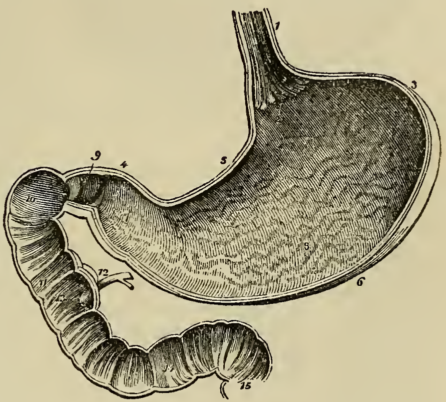

Fig. 380.—Vertical and longitudinal section of the stomach and duodenum, made so as to include the two orifices of the stomach. 1. Œsophagus; on its internal surface the plicated arrangement of the mucous membrane is shown. 2. Cardiac orifice of the stomach, around which the serrated border of the epithelium is seen. 3. Great end of the stomach. 4. Lesser or pyloric end. 5. Lesser curve. 6. Greater curve. 7. Dilatation at the lesser end of the stomach, the antrum of the pylorus. 8. Rugæ of the stomach formed by the mucous membrane; their longitudinal direction is shown. 9. Pylorus. 10. Ascending portion of the duodenum. 11. Descending portion. 12. Pancreatic duct and common bile duct close to their termination. 13. Papilla upon which the ducts open. 14. Transverse portion of duodenum. 15. Commencement of jejunum. In the interior of the duodenum and jejunum, the valvulæ conniventes are seen.

broadest part. When moderately full it is capable of holding from five to ten pints of fluid.

Structure of the Stomach.—The stomach has four coats—viz., serous, muscular, submucous, and mucous.

The **serous** coat is derived from the peritoneum and completely invests it, except at the upper and lower borders, where the anterior and posterior layers are separated by a very small interval, in which run the gastric and gastro-epiploic arteries.

The **muscular** coat consists of unstriped fibres arranged in three layers. The most external are longitudinal, and extend from the œsophageal to the pyloric orifice. They are continuous with the longitudinal fibres of the œsophagus, and are scattered over the back and front of the organ, but collected into strong bundles along the two borders. The middle layer is disposed in circles, which commence at the left extremity, and continue along the whole

body of the stomach to the pylorus, where they are gathered into a muscular ring, which forms the contractile part of that outlet. They are very thin at the great end of the stomach, but get thicker and more distinct as they approach the pylorus. Some oblique fibres, continued from the circular fibres of the œsophagus, form a partial layer within the two former. They are continued on to the cardiac orifice, and spread out from it, some of them having nearly the same direction as the circular fibres, with which indeed many become continuous.

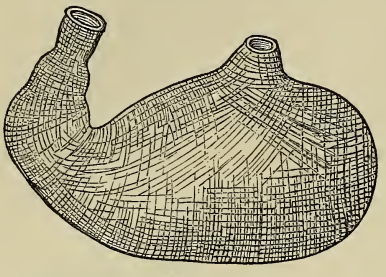

FIG. 381.—Diagram of the muscular coat of the stomach, showing the circular, oblique, and longitudinal fibres.

The **submucous** areolar tissue forms a third coat. It is loose and filamentous in structure, so that the next coat is comparatively feebly attached to the muscular coat.

The **mucous membrane** of the stomach is soft and loose, thinner at the cardiac than at the pyloric end, and of a greyish or pinkish-grey colour. It is redder in infancy than in the adult. It is so loosely connected to the muscular coat that when the stomach is distended it has a smooth, even, mucous lining: but when contracted the membrane is thrown into folds, or **rugæ**. These plaits, though not permanent, always when present assume one direction, that next the pylorus being disposed circularly, those over the rest of the interior longitudinally. The circular fold at the pylorus along with the muscular ring, constitutes the **pyloric valve.**

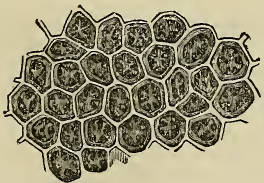

FIG. 382.—Portion of the mucous membrane of the stomach, showing the polygonal alveoli, and at the bottom of these the openings of the gastric follicles.

The surface of the mucous membrane is covered with small depressions called **alveoli**, of a polygonal form, averaging $\frac{1}{150}$ of an inch in diameter. They are deeper, more marked, and more numerous near the pylorus. In the bottom of each alveolus and in the mucous membrane between them, are to be seen minute circular orifices of tubular glands. Four or five open into each alveolus. The **gastric follicles**, as they are called, are small tubes arranged perpendicularly to the mucous surface, their closed extremities resting against the submucous tissue.

They are more numerous and longer at the pyloric than at the cardiac end of the stomach, and in the former situation are frequently divided at their deep extremities so as to form compound follicles. They vary in length from $\frac{1}{60}$ to $\frac{1}{20}$ of an inch, and in width from

$\frac{1}{500}$ to $\frac{1}{360}$ of an inch. Two kinds of glands may be distinguished; the first (which it is believed simply secrete mucus) are called **mucous glands**; they are most numerous near the pylorus, and are therefore sometimes termed **pyloric glands.** The second kind are supposed to be specially engaged in the secretion of the gastric juice, and have hence been named **peptic glands.** In both there is a basement membrane formed by flattened cells joined edge to edge, and from which processes spring, some to join the cells of the retiform tissue of the mucous membrane, and others to penetrate between the epithelial cells which line the glands. The lining cells differ in their character and arrangement in the two kinds of glands; in the mucous glands they are throughout of the columnar variety, similar to those covering the surface of the mucous membrane, the only change observable in them being that in the deeper part of the gland they become cubical in form instead of elongated. In the peptic glands the columnar epithelium is found only in the upper part (neck) of the gland, the deeper cells being spheroidal or oval, and coarsely granular (*peptic cells*); towards the bottom of the gland, however, the peptic cells do not form a continuous layer but only occur here and there, the intervals between them being filled up with polyhedral, finely granular cells (central cells of the gland). Between the glands the mucous membrane consists of connective tissue with a small amount of lymphoid tissue.

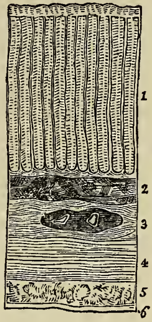

FIG. 383.—Perpendicular section of the stomach in the pyloric region, showing its coats and the gastric glands; from the pig. 1. Gastric glands. 2. Muscularis mucosæ. 3. Submucous coat, in which a vessel has been divided. 4. Transverse fibres of the muscular coat. 5. Longitudinal fibres of the muscular coat. 6. Serous coat.

Between the mucous membrane and submucous tissue a small quantity of unstriped muscular fibre is found, forming the *muscularis mucosæ*.

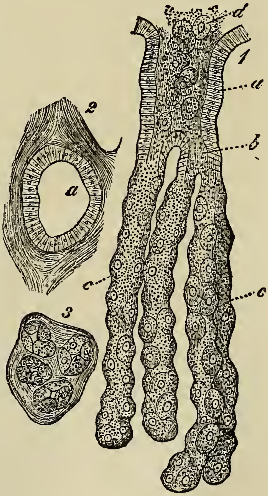

FIG. 384.—A compound peptic gland. 1, *a*. Wide entrance lined with columnar epithelium. *b*. Division. *c*, *c*. Tubules lined with peptic cells. *d*. Contents of peptic gland in process of being thrown out. 2. The opening *a* seen in transverse section. 3. Transverse section through the deep part of the glands.

SMALL INTESTINES.

The small intestine, *intestinum tenue*, is about twenty or twenty-five feet in length, and is divisible into three portions, *duodenum*, *jejunum*, and *ileum*.

The **duodenum** (called δωδεκαδάκτυλον by Herophilus), larger and more deeply seated than the rest of the small intestine, has received its name from being about equal in length to the breadth of twelve fingers (eight or ten inches). In its course it presents a horse-shoe curve; commencing at the pylorus, it ascends *obliquely* backwards to the under surface of the liver; it next descends *perpendicularly* in front of the right kidney as low as the fourth lumbar vertebra, and then passes nearly *transversely* across the third lumbar vertebra; terminating in the jejunum at the left side of the second lumbar vertebra, where it is crossed by the superior mesenteric artery and vein. It is connected with the portal eminence of the liver by means of a band of peritoneum called *ligamentum hepatico-duodenale;* and to the right kidney by another band, the *ligamentum duodeno-renale.* The duodenum is the most fixed portion of the small intestine.

The **first** or **ascending portion** of its course, between two and three inches in length, is completely enclosed by the peritoneum: it is in relation, *above* with the liver and neck of the gall-bladder; *in front* with the great omentum and abdominal parietes; and *behind* with the right border of the lesser omentum and its vessels.

The **second** or **descending portion** is situated altogether behind the peritoneum: it is in relation by its *anterior surface* with the commencement of the arch of the colon; by its *posterior surface* with the concave margin of the right kidney, the inferior vena cava, and ductus communis choledochus; by its *right border* with the ascending colon; and by its *left border* with the pancreas. The ductus communis choledochus and pancreatic duct open into the internal and posterior side of the perpendicular portion, a little below its middle.

The **third** or **transverse portion** of the duodenum, the longest and narrowest of the three, lies between the diverging layers of the transverse meso-colon, with which and with the stomach it is in relation *in front; above*, it is in contact with the lower border of the pancreas, the superior mesenteric artery and vein being interposed; and, *behind*, it rests on the inferior vena cava and aorta.

The **jejunum** (*jejunus*, empty) is named from being generally found empty. It forms the upper two-fifths of the small intestine; commencing at the bend of the duodenum, on the left side of the second lumbar vertebra, and terminating in the ileum. It is thicker to the touch than the rest of the intestine, has a pinkish tinge from containing more mucous membrane than the ileum, and is situated in the umbilical region and left iliac fossa.

The **ileum** (εἴλειν, to twist, to convolute) includes the remaining three-fifths of the small intestine. It is somewhat smaller in calibre, thinner in texture, and paler than the jejunum; but there is no mark by which to distinguish the termination of the one or the commencement of the other. It is situated in the umbilical and hypogastric region and pelvic cavity, and terminates in the right iliac fossa, by opening at an obtuse angle into the commencement of the colon.

The small intestines form in their course a double curve resembling the letter S, the upper curve to the right representing that of the duodenum; and the lower to the left that of the jejunum and ileum to the termination of the latter in the colon.

The jejunum and ileum are surrounded, above and at the sides, by the colon; in front they are in relation with the omentum and abdominal parietes; they are retained in position by the mesentery, which connects them with the posterior wall of the abdomen; and below they descend into the cavity of the pelvis. At about the lower third of the ileum a pouch-like process or diverticulum of the intestine is occasionally seen. This is a vestige of embryonic structure, and results from the obliteration of the omphalo-mesenteric or vitelline duct at a short distance from the cylinder of the intestine.

LARGE INTESTINE.

The large intestine, five or six feet and sometimes more in length, prismoid in form, sacculated and thicker than the small intestine, tapers gradually from above downwards, and is divided into *cæcum*, *colon*, and *rectum*. It is distinguished from the small intestine by four characters, namely, its size, sacculation, the existence of three longitudinal bands, and the presence in connection with it of little fringes of fat called *appendices epiploicæ*.

The **cæcum** (caput coli) is the blind pouch, or cul-de-sac, about two inches and a half in length, situated at the commencement of the large intestine. It is lodged in the right iliac fossa, and retained in its place by the peritoneum which passes over its anterior surface; its posterior surface is connected by loose areolar tissue with the iliac fascia. Attached to its extremity is the **appendix vermiformis**, a long worm-shaped tube, the rudiment of the lengthened cæcum found in all mammiferous animals except man and the higher quadrumana.

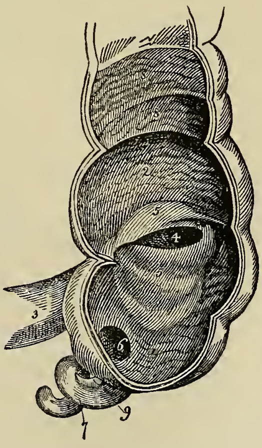

FIG. 385.—The cæcum, showing its appendix, entrance of the ileum, and ileo-cæcal valve. 1. Cæcum. 2. Commencement of colon. 3. Ileum. 4. Aperture of entrance of the ileum into the large intestine. 5, 5. Ileo-cæcal valve. 6. Aperture of appendix vermiformis cæci. 7. Appendix vermiformis. 8, 8. Sacculi of the colon, separated by valvular septa. 9. Falciform frænum of appendix vermiformis.

The appendix varies in length from one to five or six inches; it is about equal in diameter to a goose-quill, and is connected with the posterior and left aspect of the cæcum near the extremity of the

ileum. It is usually more or less coiled upon itself, and retained in that coil by a falciform duplicature of peritoneum. Its canal is extremely small, and the orifice by which it opens into the cæcum not unfrequently provided with an incomplete valve. Occasionally the peritoneum invests the cæcum so completely as to constitute a meso-cæcum, which permits of an unusual degree of movement in this portion of the intestine, and serves to explain the occurrence of hernia of the cæcum on the right side. The cæcum is the most dilated portion of the large intestine, and is distinguished from the colon externally by the constriction corresponding with the entrance of the ileum, and internally by the ileo-cæcal or ileo-colic valve.

The **colon** is divided into *ascending*, *transverse*, and *descending.* The **ascending colon** passes upwards from the right iliac fossa, through the right lumbar region to the under surface of the liver. It then bends inwards and crosses the upper part of the umbilical region under the name of **transverse colon**; and, on the left side descends, **descending colon**, through the left lumbar region to the left iliac fossa, where it makes a remarkable curve upon itself, which is called the **sigmoid flexure.**

The **ascending colon,** the most dilated portion of the large intestine, next the cæcum, is retained in position in the abdomen either by the peritoneum passing simply in front of it or by a narrow meso-colon. It is in relation *in front* with the small intestine and abdominal parietes; *behind* with the quadratus lumborum muscle and right kidney; *internally* with the small intestine and perpendicular portion of the duodenum; and by its *upper extremity* with the under surface of the liver and gall-bladder.

The **transverse colon,** the longest portion of the large intestine, forms a curve across the cavity of the abdomen, the convexity of the curve looking forwards and sometimes downwards. It is in relation, by its *upper surface*, with the liver, gall-bladder, stomach, and lower extremity of the spleen; by its *lower surface*, with the small intestine; by its *anterior surface*, with the anterior layers of the great omentum and abdominal parietes; and, by its *posterior surface*, with the transverse meso-colon.

The **descending colon** is smaller in calibre, and situated more deeply than the ascending colon; its relations are similar.

The **sigmoid flexure,** the narrowest part of the colon, curves upwards and to the right, then downwards and to the left, and is retained in its place by a meso-colon. It is in relation, *in front*, with the small intestine and abdominal parietes; and *behind* with the iliac fossa.

The **rectum,** the termination of the large intestine, seven or eight inches in length, has received its name, not so much from the direction of its course, as from the straightness of its form in comparison with the colon. It descends from opposite the left sacro-iliac symphysis, in front of the sacrum, forming a gentle curve to the right side, and then returning to the middle line; opposite the extremity of the coccyx it curves backwards to terminate in the

anus at about an inch in front of the apex of that bone. The rectum, therefore, forms a double flexure in its course, the one being directed from side to side, the other from before backwards. It is smaller in calibre at its upper part than the sigmoid flexure, but becomes gradually larger as it descends, and its lower extremity, previously to its termination at the anus, forms a dilatation of considerable but variable magnitude. It is not sacculated like the colon, and has no separate longitudinal bands on it.

With reference to its relations, the rectum is divided into three portions; the *first*, including half its length, extends to about the middle of the sacrum, is completely surrounded by peritoneum, and connected to the sacrum by means of the meso-rectum. This portion is in relation above with the left sacro-iliac symphysis; and below, with the branches of the internal iliac artery, sacral plexus of nerves and left ureter; one or two convolutions of the small intestine are interposed between the front of the rectum and the bladder in the male; and between the rectum and the uterus with its appendages in the female. The *second portion*, about three inches in length, is closely attached to the surface of the sacrum, and is at first covered by peritoneum on the front and sides, but lower down has that membrane only in front; it is in relation by its lower part with the base of the bladder, vesiculæ seminales, and prostate gland; and in the female with the vagina. The *third portion* curves backwards from opposite the prostate gland and tip of the coccyx to terminate in the anus; it is embraced by the levatores ani, and is about one inch and a half in length. This portion is separated from the membranous part of the urethra by a triangular space; in the female the triangular space intervenes between the vagina and rectum, and constitutes by its base the perineum.

The **anus** is situated at a little more than an inch in front of the extremity of the coccyx. The integument around it is covered with hairs, and is thrown into numerous radiated plaits which are obliterated during the passage of fæces. The margin of the anus is provided with an abundance of sebaceous glands, and the epidermis may be seen terminating by a fringed and scalloped border, at a few lines above the extremity of the opening.

STRUCTURE OF THE INTESTINAL CANAL.

The intestinal canal, like the stomach, has four coats—*serous*, *muscular*, *submucous*, and *mucous*.

Serous Coat.—The alimentary canal has a serous layer derived from the peritoneum.

The **first** or **ascending portion of the duodenum** is completely included by the serous membrane, with the exception of the points of attachment of the omenta. The **descending portion** has only a partial covering on its anterior surface, derived from the right meso-colon. The **transverse portion** is also behind the peritoneum,

being situated between the two layers of the transverse meso-colon, and has but a partial covering. The rest of the **small intestine** is completely invested by it, excepting along the concave border, to which the mesentery is attached. The **cæcum** is more or less invested by the peritoneum, the more frequent disposition being that in which the intestine is surrounded for three-fourths only of its circumference. The **ascending** and **descending colon** are covered by the serous membrane only in front. The **transverse colon** is invested completely, with the exception of the lines of attachment of the great omentum and transverse meso-colon. And the **sigmoid flexure** is entirely surrounded, with the exception of the part corresponding with the junction of the left meso-colon. The upper third of the **rectum** is completely enclosed by the peritoneum; the middle third has an anterior covering only, and the inferior third none at all.

Muscular Coat.—The muscular coat of the alimentary canal is composed of two planes of fibres, external or *longitudinal*, and internal or *circular*.

In the **small intestine**, the muscular coat is thicker in the duodenum and jejunum than in the ileum; the *longitudinal fibres* are most numerous along the free border of the intestine; and the *circular fibres* are more or less oblique in direction. At the termination of the ileum the circular fibres are continued into the two folds of the ileo-cæcal valve, while the longitudinal fibres pass onwards to the large intestine.

In the **large intestine**, the *longitudinal fibres* commence at the appendix vermiformis, and are collected into three bands—anterior, broad; and two narrower bands, one placed posteriorly and the other laterally. The anterior band corresponds in the transverse colon to the line of attachment of the great omentum; the posterior band is at the attached border of the colon; and the lateral one lies on the inner aspect of the ascending and descending colon, and under surface of the transverse colon. These bands, the *ligamenta coli*, are nearly one-half shorter than the intestine, and serve to maintain the sacculated structure of the cæcum and colon. In the *descending colon* the posterior bands usually unite and form a single band. From this point the bands are continued downwards upon the sigmoid flexure to the rectum, around which they spread out and form a thick and very muscular longitudinal layer. The *circular fibres* in the cæcum and colon are thin; in the rectum they are thicker, and near its lower extremity are aggregated into the thick muscular band which is known as the internal sphincter ani.

The **muscular fibres** of the alimentary canal are of the *smooth* kind, excepting at the commencement and termination, where they are striated; the *striated fibres* form the chief bulk of the muscular coat of the œsophagus, as far as the thorax, they then become smooth, first in the circular and then in the longitudinal layer. In the lower part of the rectum, the striated fibres again make their appearance, and increase in numbers to its extremity.

Submucous Coat.—The *submucous* or *areolar coat* is a moderately thick stratum of areolar tissue which sustains the vessels, nerves, and glands of the mucous membrane, and connects it to the muscular coat; it is thin and dense in the œsophagus; thicker and more distinct in the stomach; and thicker than the other coats in the small intestine, where it is loose in texture, devoid of fat, and easily distended with air, excepting at Peyer's glands, where it is closely adherent. It is also thicker in the upper part of the small intestine than below, and is one cause of the greater thickness of the duodenum and jejunum; moreover, it enters into the structure of the valvulæ conniventes.

Mucous Coat.—In the **small intestine** the mucous membrane is thinner than in the stomach; it is smooth in the upper fourth of the *duodenum*, but raised into crescentic folds, **valvulæ conniventes** (valves of Kerkring), in its lower three-fourths; the valvulæ conniventes being continued throughout the jejunum, and extending as far as the middle of the ileum. On the posterior and inner side of the descending portion of the duodenum is a longitudinal ridge or crest, *plica longitudinalis*, about an inch in length, caused by the oblique passage through the walls of the intestine, of the ductus communis choledochus; and at the lower and most prominent part of this crest is the aperture of termination of that duct and the pancreatic duct. The valvulæ conniventes are narrow at their commencement, but quickly become larger; and at the lower part of the duodenum and upper part of the jejunum, where they are largest, have a breadth of several lines. In the lower part of the jejunum and upper part of the ileum they become narrower and more scanty, and are finally lost altogether at about the middle of the latter. Each fold or valve extends for about one-half or three-fourths around the cylinder of the intestine; and as they spring from all sides of its circumference, have the appearance of circular septa. The jejunum owes it considerable thickness to these valves; and as they are small in the upper half of the ileum and wanting in its lower half, the thinness of the ileum is due to their absence. The valvulæ conniventes differ from the rugæ described as present in the stomach, in that they are not obliterated when the wall of the canal is put on the stretch.

Ilio-cæcal Valve.—At the termination of the ileum in the large intestine, the mucous membrane forms two semilunar folds, strengthened by the muscular coat. The termination of the ileum is oblique and flattened, and constitutes the division between the cæcum and colon, the two folds of mucous membrane being the *ileo-cæcal* or *ileo-colic valve* (valve of Bauhin or valve of Tulpius). The position of these folds is such that one belongs to the cæcum, the other to the colon, the opening between them being oblong and oval, and not inaptly compared to a button-hole; moreover, the colic flap somewhat overlaps the cæcal flap, and is so disposed in relation to the entrance of the ileum, that the contents of the small bowel are necessarily discharged into the cæcum. The upper or ileo-colic fold

is horizontal in its direction, the lower or ileo-cæcal is nearly vertical; both folds are prolonged on each side for some distance beyond the ends of the opening, these prolongations being called *frenula* or *retinacula.*

In the **cæcum** and **colon** the mucous membrane is smooth, and lines the surfaces of the folds which form the boundaries of the sacculi of the large intestine. In the **rectum** it forms three valvular folds, one of which is situated near the commencement of the intestine; the second, extending from the side of the tube, is placed opposite the middle of the sacrum; and the third, which is the largest and most constant, projects from the anterior wall of the bowel opposite the base of the bladder. Besides these folds, the membrane in the empty state of the intestine is thrown into longitudinal plaits somewhat similar to those of the œsophagus; these have been named the *columns* of the rectum. The mucous membrane of the rectum is connected to the muscular coat by a loose areolar tissue, as in the œsophagus.

One character serves infallibly to distinguish the mucous membrane of the small intestine from that of the large, namely, that the

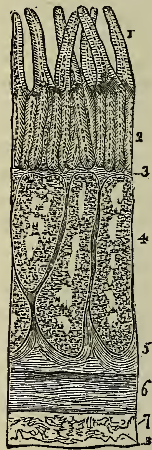

Fig. 386.—Mucous membrane of the small intestine, showing villi. In the hollows between the villi are seen the apertures of Lieberkühn's follicles (*b*); and near the bottom of the figure is a zone of follicles (*a*), surrounding a solitary gland.

Fig. 387.—Section of the lower part of the ileum of the calf, through a Peyer's patch. 1. Villi. 2. Lieberkühn's follicles. 3. Muscularis mucosæ. 4. Peyer's patch. 5. Deep portion of the submucous coat. 6. Circular layer of the muscular coat. 7. Longitudinal layer of the muscular coat. 8. Serous coat.

former is studded over throughout by minute conical processes called **villi**, which are entirely absent from the latter.

Villi and Glands.—Besides the larger folds on the mucous membrane, there are certain more minute structures, which can only be well studied by microscopic observation. They are the intestinal villi, Lieberkühn's follicles, Brunner's glands, the solitary glands, and Peyer's patches.

The **villi** are little conical or club-shaped projections, about one-fourth of a line in length. They are confined to the small intestine, and are so thickly set, especially at the upper part of the tube, that they resemble the nap of velvet, and give rise to the villous or velvety appearance presented by a well-washed piece of intestine suspended in water. In structure each villus consists of a process of the basement membrane, which is covered with a layer of columnar epithelial cells. In its interior are contained a network of capillaries, lymphoid tissue, connective tissue, and a small lacteal vessel, the latter being the agent for the selective absorption of nutriment. The lacteal lies in the centre, and has adherent to it the cells of the lymphoid tissue, which again lie in contact with the basement membrane, through which they are in immediate relation with the epithelial cells. Through this channel the nutritive materials taken up by the epithelial cells are transmitted to the lacteal, though in what precise method has not yet been determined. Each villus contains some fibres of unstriped muscle prolonged into it from the muscularis mucosæ.

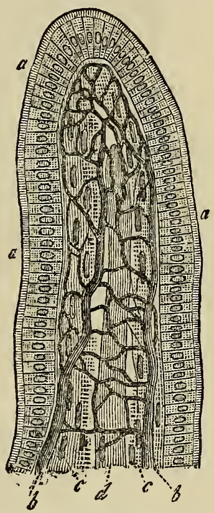

Fig. 388. — An intestinal villus. *a, a, a.* Columnar epithelium. *b, b.* Capillary network. *c, c.* Longitudinal muscular bundles. *d.* Lymphatic capillary.

Lieberkühn's crypts or **follicles** are minute tubules about $\frac{1}{20}$ of a line in length, somewhat like the gastric follicles, but smaller. They are found all over the surface of the small intestine, between the villi, and forming circles round the nodules of Peyer's patches; they are both more numerous and larger in the large intestine. They are composed of an involution of the basement membrane, and their epithelium is columnar.

Brunner's Glands.—These **racemose** or **lobulated glands** are small yellowish and flattened glands, each surrounded by a small capsule of areolar tissue, and situated in the submucous coat of the alimentary canal. They are identical in structure with the racemose glands of the mouth, and open on the surface of the mucous membrane by means of an excretory duct. They are confined to the **duodenum**, extending from the pylorus, where they are most abundant, to the entrance of the ductus communis choledochus. Von Brunn compared them to a second pancreas, and after him they have been named *Brunner's glands* or *duodenal* glands. Their average size is a quarter to half a line, and they

secrete a clear alkaline mucus, in which no formed elements, such as cells or nuclei, are present.

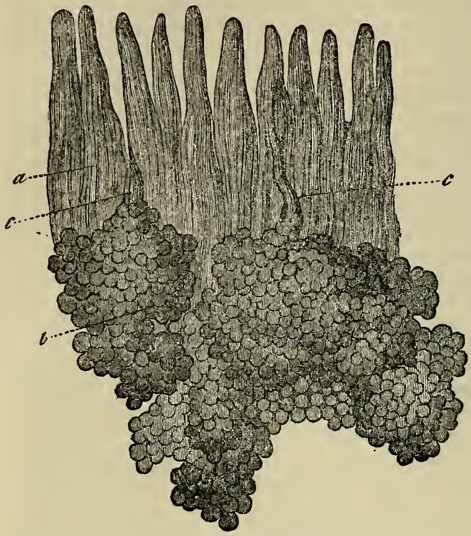

FIG. 389.—Brunner's glands from the duodenum. *a.* Villi. *b.* Bodies of the glands. *c, c.* Excretory ducts opening between the villi.

Solitary Glands.—These glands (glandulæ solitariæ) are called also from the shape of their sac *lenticular* and *vesicular*. In structure they consist of spheroidal masses of retiform or lymphoid tissue, the interstices of which are crowded with lymph cells; each mass is surrounded by a very fine capillary plexus. The sacculi are embedded in the substance of the mucous membrane, by which they are surrounded on all sides, and they form a prominence on the surface, which in the small intestine is studded with villi.

The solitary glands are met with in every part of the cylinder of

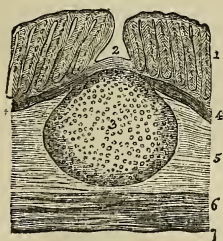

FIG. 390.—Solitary gland from the colon of a child, as shown in a section of the intestine. 1. Lieberkühn's glands. 2. Depression on the surface of the membrane corresponding with the central prominence of the gland. 3. The gland. 4. Muscular layer of the mucous coat. 5. Submucous coat. 6. Muscular coat. 7. Serous coat.

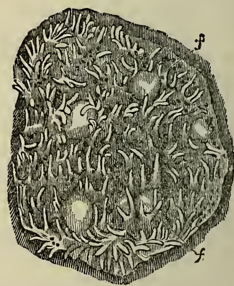

FIG. 391.—Surface aspect of a portion of the intestinal mucous membrane, showing the solitary glands, *f, f,* and the villi.

the bowel, sometimes singly and sometimes in groups, and more

numerously in the jejunum than in the ileum. In the large intestine they are grouped closely together in the appendix vermiformis, and are abundant in the cæcum and rectum, but less numerous in the colon; they are larger in the large than in the small intestine.

Peyer's glands or **patches** (glandulæ agminatæ) are confined to the jejunum and ileum, being larger and more numerous in the lower part of the latter. To the naked eye they appear oval patches of mucous membrane, of about from one to three inches in length, and about an inch in breadth. They are paler in colour than the surrounding membrane, and are somewhat raised above the general level. They run in the direction of the length of the intestine, and are generally found on the side opposite to the attached border. On more close inspection they are found to be formed of a collection of solitary glands in close proximity to each other; hence their name, "aggregate glands." The surface mucous membrane in which they are embedded is free from villi, and the Lieberkühn follicles are arranged in circles round each nodule. The patches vary from twenty to forty in number. They are enormously enlarged and subsequently ulcerated in enteric fever, of which they form the special lesion.

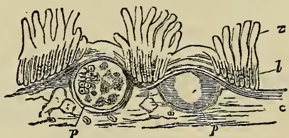

Fig. 392.—Vertical section of the intestinal mucous membrane, bringing into view two Peyerian bodies. *z.* villi. *l.* follicles of Lieberkühn. *c.* submucous coat. *p, p.* Peyerian nodules, one of them shown in section, the other not cut open.

Vessels of the Mucous Coat.—The distribution of the finer arterial vessels and capillaries in the mucous membrane of the intestinal canal, in relation to the glands, is worthy of attention. The small arteries divide into fine capillaries in the submucous coat; these fine capillaries enter the spaces between the tubular glands, and form by their communications a plexus around the glands, in their course to the surface. Having reached the surface of the mucous membrane, the capillaries become increased in size, and form a horizontal plexus around the apertures of the glands, and these larger capillaries taking a retrograde course, unite to form small venous trunks, by which the blood is returned to the venous circulation. Hence the glands are provided for their secreting function with fine capillaries, while the capillaries which contribute to the nutrition and secretion of the surface of the mucous membrane are of a coarser kind.

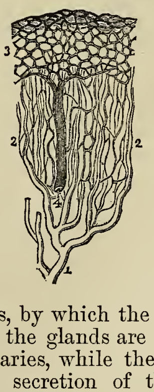

Fig. 393.—Circulation in the mucous membrane of the intestine. 1. Artery. 2. Fine capillary network, proceeding from the artery and surrounding the tubular glands. 3. Superficial capillary network around the mouths of the tubular glands. 4. Vein formed by the union of capillaries returning the blood of the superficial capillary network.

Vessels and Nerves of the Alimentary Canal.—The *arteries*

of the alimentary canal, as they supply the tube from above downwards, are—the pterygo-palatine, ascending pharyngeal, superior thyroid, and inferior thyroid, in the neck; œsophageal in the thorax; gastric, hepatic, splenic, superior and inferior mesenteric, in the abdomen; and inferior mesenteric, internal iliac, and internal pudic, in the pelvis. The *veins* from the abdominal alimentary canal unite to form the vena portæ. The *lymphatics* and *lacteals* open into the thoracic duct.

The *nerves* of the pharynx and œsophagus are derived from the glosso-pharyngeal, pneumogastric, and sympathetic. The nerves of the stomach are the pneumogastric, and sympathetic branches from the solar plexus; and those of the intestinal canal are the superior and inferior mesenteric and hypogastric plexuses. The extremity of the rectum is supplied by the inferior sacral nerves from the spinal cord.

The nerves distributed to the small intestine form two plexuses, one between the longitudinal and circular muscular fibres, and the other in the submucous tissue: the former is described as **Auerbach's plexus** (plexus myentericus), it gives off a number of minute filaments which ramify in the midst of the muscular fibres and are distributed to them; the latter is named **Meissner's plexus**, it consists of fibres which are much finer than those of the intermuscular plexus, and pass to the mucous membrane. Both plexuses are remarkable for the large number of minute ganglia which they contain.

THE LIVER.

The liver is a conglomerate gland of large size, appended to the alimentary canal, and performing the double office of separating impurities from the venous blood of the chylopoietic viscera previously to its return into the general venous circulation, and of secreting a fluid necessary to chylification, the bile. It is the largest gland in the body, weighing about four pounds, and measuring through its longest diameter about twelve inches. It is situated in the right hypochondriac region, and extends across the epigastrium into the left hypochondrium, frequently reaching, by its left extremity, the upper end of the spleen. It is placed obliquely in the abdomen; its convex surface looking upwards and forwards, the concave downwards and backwards. The anterior border is sharp and free, and marked by a deep notch, and the posterior rounded and broad. It is in relation, superiorly and posteriorly, with the diaphragm; inferiorly with the stomach, ascending portion of the duodenum, transverse colon, right supra-renal capsule, and right kidney; and corresponds, by its free border, with the lower margin of the ribs.

Ligaments.—The liver is retained in its place by five ligaments, four of which are duplicatures of the peritoneum, situated on the

convex surface of the organ; the fifth is a fibrous cord which passes through a fossa in its under surface, from the umbilicus to the inferior vena cava. They are the—

Longitudinal,	Coronary,
Two lateral,	Round.

The **longitudinal ligament** (broad, suspensory or falciform) is an antero-posterior fold of peritoneum, extending from the notch in the anterior margin of the liver to its posterior border. Between its two layers, in the anterior and free margin, is the round ligament.

The **lateral ligaments** are formed by the two layers of peritoneum, which pass from the under surface of the diaphragm to the posterior border of the liver; they correspond with its lateral lobes.

The **coronary ligament** is formed by the separation of the two layers forming the lateral ligaments near their point of convergence. The posterior layer is continued unbroken from one lateral ligament

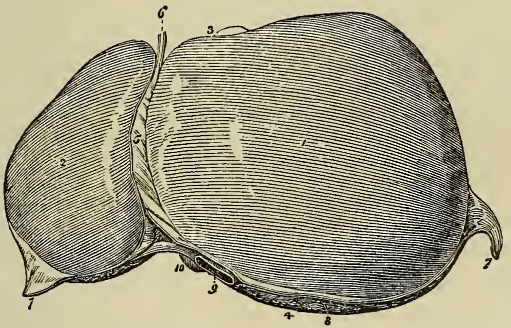

FIG. 394.—Upper surface of the liver. 1. Right lobe. 2. Left lobe. 3. Anterior or free border. 4. Posterior or rounded border. 5. Broad ligament. 6. Round ligament. 7, 7. The two lateral ligaments. 8. The space left uncovered by the peritoneum, and surrounded by the coronary ligament. 9. Inferior vena cava. 10. Point of the lobus Spigelii. 3. Fundus of the gall-bladder seen projecting beyond the anterior border of the right lobe.

to the other; but the anterior quits the posterior at each side, and is continuous with the corresponding layer of the longitudinal ligament. In this way a large oval surface on the posterior border of the liver is left uncovered by peritoneum, and is connected to the diaphragm by areolar tissue. This space is formed principally by the right lateral ligament, and is pierced near its left extremity by the inferior vena cava, previously to the passage of that vessel through the tendinous opening in the diaphragm.

The **round ligament** is a fibrous cord resulting from the obliteration of the umbilical vein, and situated between the two layers of peritoneum in the anterior border of the longitudinal ligament.

It may be traced from the umbilicus through the longitudinal fossa of the under surface of the liver to the inferior vena cava, to which it is connected.

Fissures.—The under surface of the liver is marked by five fissures, which divide its surface into five compartments or lobes, two principal and three minor lobes; they are the—

Fissures.	**Lobes.**
Longitudinal fissure,	Right lobe,
Fissure for the ductus venosus,	Left lobe,
Transverse fissure,	Lobus quadratus,
Fissure for the gall-bladder,	Lobus Spigelii,
Fissure for the vena cava.	Lobus caudatus.

The **longitudinal fissure** is a deep groove running from the notch, *incisura umbilicalis*, in the anterior margin of the liver, to the posterior border of the organ. At about one-third from its posterior extremity it is joined by a short but deep fissure, the transverse, which meets it transversely from the under part of the right lobe.

The longitudinal fissure in front of this junction lodges the fibrous cord of the umbilical vein, and is generally crossed by a band of hepatic substance called the *pons hepatis.*

The **fissure for the ductus venosus** is the shorter portion of the longitudinal fissure, extending from the junctional termination of the transverse fissure to the posterior border of the liver, and containing a small fibrous cord, the remains of the ductus venosus. This fissure is therefore but a part of the longitudinal fissure.

The **transverse** or **portal fissure** is the short and deep fissure, about two inches in length, through which the hepatic ducts quit and the hepatic artery and portal vein enter the liver. Hence this fissure was considered by the older anatomists as the gate of the liver, *porta hepatis;* and the large vein entering the organ at this point, was named the portal vein. At their entrance into the transverse fissure the branches of the hepatic duct are the most anterior, next those of the artery, and most posteriorly the portal vein. Besides these three structures, the nerves and lymphatics also enter the liver through this fissure.

The **fissure for the gall-bladder** is a shallow depression extending forwards, parallel with the longitudinal fissure, from the right extremity of the transverse fissure to the free border of the liver, where it frequently forms a notch, *incisura vesicalis.*

The **fissure for the vena cava** is a deep and short fissure, occasionally a circular tunnel, which proceeds from a little behind the right extremity of the transverse fissure to the posterior border of the liver, and lodges the inferior vena cava. It lies between the Spigelian lobe and the right lobe, and has opening into it the hepatic veins, by which the blood leaves the liver.

These five fissures taken collectively resemble an inverted ∀, the

base corresponding with the free margin of the liver, and the apex with its posterior border. Viewing them in this way, the two anterior branches represent the longitudinal fissure on the left, and the fissure for the gall-bladder on the right side ; the two posterior, the fissure for the ductus venosus on the left, and the fissure for the vena cava on the right; and the connecting bar, the transverse fissure.

Lobes.—The **right lobe** is four or six times larger than the left, from which it is separated, on the concave surface, by the longitudinal fissure, and on the convex, by the longitudinal ligament. It is marked on its under surface by the transverse fissure, and by the fissures for the gall-bladder and vena cava; and presents two depressions, one in front (*impressio colica*) for the curve of the ascending colon, and one behind (*impressio renalis*) for the right

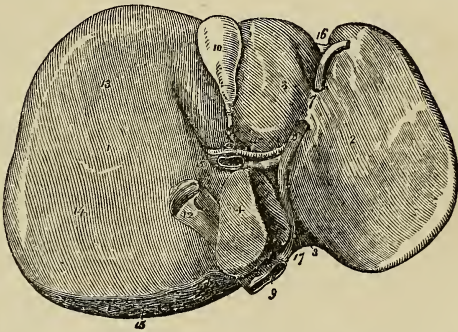

Fig. 395.—Under surface of the liver. 1. Right lobe. 2. Left lobe. 3. Lobus quadratus. 4. Lobus Spigelii. 5. Lobus caudatus; the fissure in front of 5, and running parallel with the gall-bladder, is one of the irregular fissures referred to in the text. 6. Longitudinal fissure; the figure is placed on the rounded cord, the remains of the umbilical vein. 7. Pons hepatis. 8. Fissure of the ductus venosus; the obliterated cord of the ductus is seen passing backwards to be attached to the coats of the inferior vena cava (9). 10. Gall-bladder lodged in its fissure. 11. Transverse fissure, containing, from before backwards, hepatic duct, hepatic artery, and portal vein. 12. Vena cava. 13. Depression corresponding with the curve of the colon. 14. Double depression produced by the right kidney and its supra-renal capsule. 15. Rough surface on the posterior border of the liver left uncovered by peritoneum; the cut edge of the peritoneum surrounding this surface forms part of the coronary ligament. 16. Notch on the anterior border separating the two lobes. 17. Notch on the posterior border corresponding with the vertebral column.

supra-renal capsule and kidney. Not unfrequently several small irregular fissures are found on the under surface of this lobe.

The **left lobe** is small and flattened, convex on its upper surface and concave below, where it lies in contact with the anterior surface of the stomach. It is sometimes in contact by its extremity with the upper end of the spleen, and is in relation, by its posterior border, with the cardiac orifice of the stomach and left pneumogastric nerve.

The **lobus quadratus** is a quadrilateral lobe situated on the under surface of the right lobe : it is bounded, *in front*, by the free border of the liver ; *behind*, by the transverse fissure ; to the *right*, by the gall-bladder ; and to the *left*, by the longitudinal fissure.

The **lobus Spigelii** is a small triangular lobe, also situated on

the under surface of the right lobe: it is bounded, *in front*, by the transverse fissure; and, *on the sides*, by the fissures for the ductus venosus and vena cava.

The **lobus caudatus** is a small tail-like appendage of the lobus Spigelii, from which it runs outwards like a crest into the right lobe, and serves to separate the right extremity of the transverse fissure from the commencement of the fissure for the vena cava. In some persons this lobe is well marked, in others it is small and ill-defined.

Reverting to the comparison of the fissures with an inverted ∀, it will be observed, that the quadrilateral interval, in front of the transverse bar, represents the lobus quadratus: the triangular space behind the bar, the lobus Spigelii; and the apex of the letter, the point of union between the inferior vena cava and the obliterated cord of the ductus venosus.

Vessels and Nerves.—The vessels entering into the structure of the liver are also *five* in number; they are the—

Hepatic artery,	Hepatic veins,	Lymphatics.
Portal vein,	Hepatic ducts,	

The **hepatic artery, portal vein,** and **hepatic duct** enter the liver at the transverse fissure, and ramify through portal canals to every part of the organ; so that their general direction is from below upwards, and from the centre towards the circumference.

The **hepatic veins** commence at the circumference, and proceed from before backwards, to open into the vena cava at the posterior border of the liver. Hence the branches of the two veins cross each other in their course.

The portal vein, hepatic artery, and hepatic duct are moreover enveloped in a loose areolar tissue, the capsule of Glisson, which permits them to contract upon themselves when emptied of their contents; the hepatic veins, on the contrary, are closely adherent by their parietes to the surface of the canals in which they run, and are unable to contract. By these characters the anatomist is enabled, in any section of the liver, to distinguish at once the most minute branch of the portal vein from an hepatic vein; the former will be found more or less collapsed, and always accompanied by an artery and duct, and the latter widely open and solitary.

The **lymphatics** of the liver are described in the section dedicated to those vessels.

The **nerves** of the liver are derived from the spinal and sympathetic system; the former proceed from the right phrenic and right pneumogastric nerve, the latter from the hepatic plexus.

Minute Anatomy of the Liver.

The liver is composed of *lobules*, of areolar tissue which connects them together, of the ramifications of the *portal vein*, *hepatic duct*, *hepatic artery*, *hepatic veins*, *lymphatics*, and *nerves*, and is enclosed and retained in its situation by the peritoneum.

The **lobules** are small granular bodies of about the size of a millet seed, of irregular form, and presenting a number of rounded prominences on their surface. When divided longitudinally, they have a foliated appearance, and transversely, a polygonal outline, with sharp or rounded angles, according to the smaller or greater quantity of areolar tissue contained in the liver. Each lobule is divided on its exterior into a base and a peripheral surface. The *base* corresponds with one extremity of the lobule, is flattened, and rests on an hepatic vein, which is thence named **sublobular**. The *peripheral surface* includes the rest of the surface of the lobule. In the centre of each lobule is a small vein, the **intralobular**, which is formed by the convergence of six or eight minute venules from the rounded prominences of the periphery. The intralobular vein thus constituted takes its course through the centre of the longitudinal axis of the lobule, pierces the middle of its base, and opens into the sublobular vein. The periphery of the lobule, with the exception of its base, which is always closely attached to a sublobular vein, is connected by means of its areolar tissue, with the surfaces of surrounding lobules. The interval between the lobules is the **interlobular fissure**, and the angular interstices formed by the apposition of several lobules are the **interlobular spaces.**

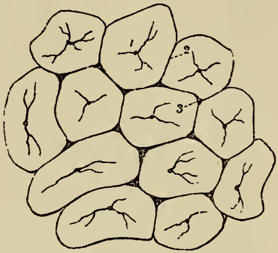

FIG. 396.—Lobules of the liver. The lobules as they are seen on the surface of the liver, or when divided transversely. 1. Intralobular vein in the centre of each lobule. 2. Interlobular fissure. 3. Interlobular space.

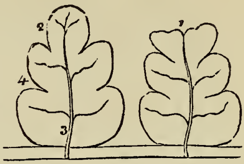

FIG. 397.—Longitudinal section of two lobules. 1. A superficial lobule, terminating abruptly, and resembling a section at its extremity. 2. A deep lobule, showing the foliated appearance of its section. 3. Intralobular vein, with its converging venules; the vein terminates in a sublobular vein. 4. External surface of the lobule.

The lobules of the centre of the liver are angular, and somewhat smaller than those of the surface, from the greater compression to which they are submitted. The superficial lobules are incomplete, and give to the surface of the organ the appearance of a transverse section.

In **ultimate structure** the lobule is composed of **hepatic cells,** of a **vascular plexus** which receives its blood exteriorly from an interlobular branch of the portal vein and transmits it internally to the intralobular vein, the radicle of the hepatic vein, and of the ultimate ramifications of the **biliary ducts.**

The **hepatic cells** are nucleolo-nucleated cells, of a polyhedral figure, measuring about $\frac{1}{1000}$ of an inch in diameter, and of a pale amber colour. They have no distinct cell-wall, and when isolated possess the power of amœboid motion; their contents are granular, and often fatty vesicles of various sizes may be observed in their interior. The cells are arranged in a network corresponding with the vascular plexus, the columns or solid portions of the network constituting the secretory portion of the gland; the vessels are not in absolute contact with the hepatic cells, but are separated from them by a membrane formed of flattened cells, the space left between this membrane and the capillary wall forming a lymph channel.

In order to understand the relations which the cells bear to the vessels and ducts, it will be necessary to trace the two latter from the transverse fissure to the interior of the liver, and to note their arrangement in the portal canals, around the lobules, and in the substance of the lobules. The portal vein, hepatic artery, and

Fig. 398.—Hepatic cells, most of which contain fat vesicles.

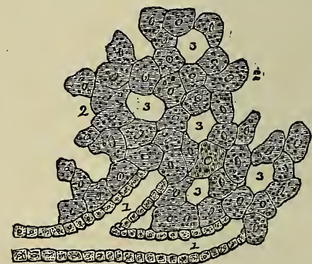

Fig. 399.—Hepatic cells forming a network. 1, 1. Hepatic ducts at margin of lobule. 2, 2. Hepatic cells arranged in columns. 3, 3. Spaces occupied by capillaries.

hepatic duct run together in the interior of the liver, being contained in channels formed by a layer of connective tissue called *Glisson's capsule*, the channels receiving the name of **portal canals**; the hepatic veins run a totally independent course, and terminate in the inferior vena cava, where it lies against the under and posterior part of the liver.

Glisson's capsule is the areolar tissue which envelops the hepatic artery, portal vein, and hepatic duct, during their passage through the transverse fissure, and which continues to surround them to the interlobular fissures. It also constitutes the proper capsule of the entire organ. Glisson's capsule is to the liver what the pia mater is to the brain; it is a fibro-vascular membrane, in which the vessels divide and subdivide to an extreme degree of minuteness; which lines the portal canals, forming sheaths for the larger vessels contained in them, and a web in which the smaller

vessels ramify. Hence arises a division of the capsule into two portions, *vaginal* and *investing*.

The vaginal portion is that which invests the hepatic artery, hepatic duct, and portal vein, in the portal canals; in the large canals it completely surrounds these vessels, but in the smaller is situated only on that side which is occupied by the artery and duct. The investing portion is that which covers the exterior of the organ.

The **portal vein** enters the liver at the transverse fissure, and ramifies throughout its structure in the portal canals; in the smaller canals Glisson's capsule only envelops the artery and duct, so that the portal vein is in direct contact with the lobules. If, therefore, the portal vein were laid open by a longitudinal incision in one of these smaller canals, the coats being transparent, the outline of the lobules, bounded by their interlobular fissures, would be as distinctly seen as on the external surface of the liver, and the smaller venous branches would be observed entering the interlobular spaces.

The branches of the portal vein are—vaginal, interlobular, and lobular. The **vaginal branches** are those which, being given off in the portal canals, have to pass through the sheath (vagina) of Glisson's capsule, previously to entering the interlobular spaces. In this course they form an intricate plexus, **vaginal plexus**, in the capsule of Glisson, and this plexus surrounds the vessels, as does the capsule in the larger canals, and occupies the capsular side only in the smaller canals. The **interlobular branches** are given off from the vaginal portal plexus where it exists, and directly from the portal veins, in that part of the smaller canals where the coats of the vein are in contact with the walls of the canal. They then enter the interlobular spaces and divide into branches, which cover with their ramifications every part of the surface of the lobules, with the exception of their bases and those extremities of the superficial lobules which appear on the surfaces of the liver. The **lobular branches** are derived from the interlobular veins; they form a plexus within each lobule, and converge from

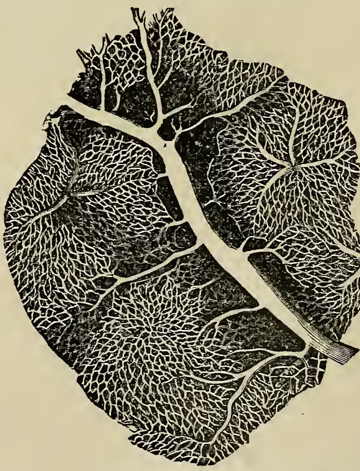

FIG. 400.—Rabbit's liver injected, showing an interlobular branch, the lobular plexuses, and intralobular veins.

the circumference towards the centre, where they terminate in the minute radicles of the intralobular vein. This plexus, interposed between the interlobular portal veins and the intralobular hepatic vein, constitutes the venous part of the lobule, and is called the **lobular venous plexus.** The regular islets of the substance of the lobules, seen between the meshes of this plexus by means of the microscope, are the network of hepatic cells.

The portal vein returns the venous blood from the chylopoietic viscera, to be circulated through the lobules; it also receives the blood which results from the distribution of the hepatic artery.

The **hepatic artery** enters the liver with the portal vein and hepatic duct, and ramifies with those vessels through the portal canals. Its branches are—vaginal, interlobular, and capsular. The **vaginal branches**, like those of the portal vein and hepatic duct, form a **vaginal plexus**, which exists throughout the whole extent of the portal canals, with the exception of that side of the smaller canals which corresponds with the artery. The **interlobular branches**, arising from the vaginal plexus and from the parietal side of the artery (in the smaller canals), ramify through the interlobular fissures, and are principally distributed to the coats of the interlobular ducts. The **capsular branches** ramify within the capsule, accompanied by small veins.

The **hepatic veins** commence in the substance of each lobule by minute venules, which receive the blood from the lobular venous plexus, and converge to form the intralobular vein. The **intralobular vein** passes through the central axis of the lobule, and through the middle of its base, to terminate in a sublobular vein; and the union of the sublobular veins constitutes the hepatic trunks, which open into the inferior vena cava. The hepatic venous system consists, therefore, of three sets of vessels; intralobular veins, sublobular veins, and hepatic trunks.

The **sublobular veins** are contained in canals formed solely by the bases of the lobules, with which, from the absence of Glisson's capsule, they are in immediate contact. Their coats are thin and transparent; and if they be laid open by a longitudinal incision, the bases of the lobules will be distinctly seen, separated by interlobular fissures, and perforated through the centre by the opening of the intralobular vein.

The **hepatic trunks** are formed by the union of the sublobular veins; they have very thin walls and are in almost immediate contact with the lobules, even the larger veins being only separated by a small quantity of areolar tissue. They proceed from before backwards, and terminate, by two large openings (corresponding with the right and left lobe of the liver) and several smaller apertures, in the inferior vena cava.

The **hepatic duct**, entering the liver at the transverse fissure, divides into branches, which ramify through the portal canals, with the portal vein and hepatic artery, to terminate in the lobules; its branches are—vaginal, interlobular, and lobular.

The **vaginal branches** ramify through the capsule of Glisson, and form a **vaginal biliary plexus**, which, like the vaginal portal plexus, surrounds the vessels in the large canals, but is deficient on that side of the smaller canals against which the duct is placed. The **interlobular branches** proceed from the vaginal biliary plexus, where it exists, and directly from the hepatic duct on that side of the smaller canals against which the duct is placed. They enter the interlobular spaces, and ramify between the lobules in the interlobular fissures, then pass into the lobules and form a very fine plexus.

The coats of the duct are very vascular, and supplied with a number of mucous glands, which are distributed irregularly in the larger, but are arranged in two parallel longitudinal rows in the smaller ducts.

Arrangement of the Ducts within the Lobules.—From the interlobular ducts numerous and minute capillaries have their

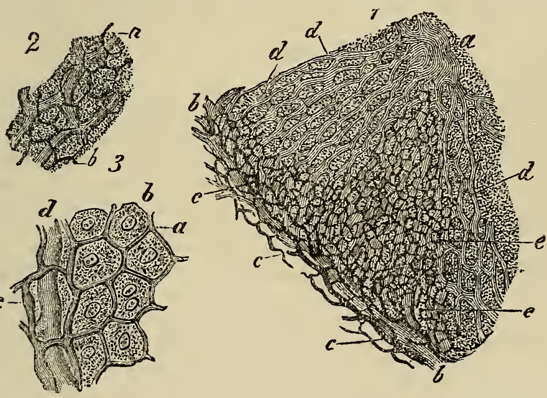

FIG. 401.—Biliary capillaries from the rabbit's liver. 1. Part of a lobule. *a*. Intralobular vein. *b*, *b*. Interlobular vein. *c*, *c*, *c*. Biliary ducts. *d*, *d*, *d*. Lobular venous plexus. *e*, *e*, *e*. Biliary capillaries. 2. Biliary capillaries (*b*) in their relation to the capillaries of the vascular system (*a*). 3. Biliary capillaries in their relation to the hepatic cells. *a*. Biliary capillaries. *b*. Hepatic cells. *c*. Biliary ducts. *d*. Capillaries of the blood-vessels.

origin; they enter into the interior of the lobule and form a fine plexus, with cubical meshes, extending entirely across the lobule. These **biliary capillaries** pass between the cells, and may be seen in cross sections of a lobule as minute pores at the points of contact of the cells; they surround and enclose each cell excepting on the side presented to the wall of the vascular capillary. As it has not been satisfactorily established that these channels possess independent walls, they are called by some authors **intercellular passages**, but from their being continuous with the fine ducts in the interlobular fissures and from certain other considerations, very fine walls

are believed to exist. The hepatic cells are placed between the biliary capillaries and the blood capillaries; they are thus in relation on the one side with the vessels containing the blood from which the bile is to be formed, and on the other with the ducts which carry that secretion away.

Summary.—The liver has been shown to be composed of *lobules;* the lobules (excepting at their bases) are connected together by areolar tissue, the vessels are supported, and the whole organ is enclosed by *Glisson's capsule*, the arrangement being such that the base of every lobule in the liver is in contact with an hepatic vein (sublobular).

The **portal vein** distributes its numberless branches through portal canals which are channelled through every part of the organ; it brings the returning blood from the chylopoietic viscera; it collects also the venous blood from the ultimate ramifications of the hepatic artery in the liver itself. It gives off branches in the canals, which are called *vaginal*, and form a venous *vaginal plexus;* these give off *interlobular branches*, and the latter enter the lobules and form *lobular venous plexuses*, from the blood circulating in which the bile is secreted.

The **bile** is received from the hepatic cells by the *biliary capillaries*, and from them passes into the *interlobular ducts;* it is thence poured into the biliary *vaginal plexus* of the portal canals, and thence into the excreting ducts, by which it is carried to the duodenum and gall-bladder, after being mingled in its course with the secretion from numberless mucous glands in the walls of the ducts.

The **hepatic artery** distributes branches through every portal canal; gives off *vaginal branches* which form a vaginal hepatic plexus, from which the *interlobular branches* arise, and these latter terminate ultimately in the lobular venous plexuses of the portal vein. The artery ramifies abundantly in the coats of the hepatic ducts, enabling them to provide their mucous secretion, and supplies the vasa vasorum of the portal and hepatic veins, and the nutrient vessels of the entire organ.

The **hepatic veins** commence in the centre of each lobule by minute radicles, which collect the impure blood from the lobular venous plexus and convey it into the *intralobular veins;* these open into the *sublobular veins*, and the sublobular veins unite to form the large hepatic trunks by which the blood is carried into the vena cava.

Lymphatics and Nerves.—The *lymphatic* vessels accompany the portal vein through the portal canals and into the interlobular fissures; they originate in the spaces described above as separating the capillaries from the biliary cells. There are also superficial lymphatic plexuses beneath the peritoneum, those on the upper convex surface communicating with the lymphatics of the diaphragm and thorax. The *nerves* form the hepatic plexus, and are derived from the solar plexus and the left pneumogastric and right phrenic nerves.

Fœtal Liver.—The liver is the first formed abdominal organ in the embryo, consisting primarily of two small masses of cells, appertaining, the one to the epithelial, the other to the vascular layer. The cells rapidly increase in number, the epithelial cells forming solid cylinders which ramify and anastomose with each other, and finally constitute the secretory portion of the gland; the other cells included within the network of the former constituting the areolar and vascular structure of the organ. Subsequently the solid cylinders are hollowed in their interior and form the biliary ducts. At the third week the liver fills the whole abdomen, and is one-half the weight of the entire embryo. At the fourth month the liver is of immense size in proportion to the bulk of the fœtus. At birth it is of very large size, and occupies the whole upper part of the abdomen. The left lobe is as large as the right, and the falciform ligament corresponds with the middle line of the body. The liver diminishes rapidly after birth, probably from obliteration of the umbilical vein.

GALL-BLADDER.

The gall-bladder (fig. 395) is the reservoir of the bile; it is a pyriform sac, situated in a fossa on the under surface of the right lobe of the liver, and extending from the right extremity of the transverse fossa to the free margin. It is divided into a body, fundus, and neck; the fundus or broad extremity in the natural position of the liver is placed downwards, and frequently projects beyond the free margin of the liver, while the neck, small and constricted, is directed upwards. This sac is composed of three coats, serous, fibrous, and mucous. The **serous coat** is partial, is derived from the peritoneum, and covers that side only which is unattached to the liver. The **middle** or **fibrous coat** is a thin but strong fibrous layer, composed of dense areolar tissue, and connected on the one side with the liver, on the other with the peritoneum. There also exists in this layer a stratum of smooth muscular fibres, which are longitudinal and circular in direction. The **internal** or **mucous coat** is but loosely attached to the fibrous layer; it is everywhere raised into minute rugæ, which give it a beautifully reticulated appearance; and it forms, at the neck of the sac, a spiral valve. It is continuous through the hepatic duct with the mucous membrane lining the ducts of the liver, and through the ductus communis choledochus, with the mucous membrane of the alimentary canal. It is coated on its surface with a columnar epithelium.

The **biliary ducts** are—the hepatic, cystic, and ductus communis choledochus.

The **hepatic duct**, nearly two inches long, is formed in the transverse fissure of the liver by the junction of two ducts which proceed from the right and left lobe. It joins the cystic duct at an acute angle, and the common duct resulting from their union is the ductus communis choledochus.

The **cystic duct**, about an inch in length, passes inwards from the neck of the gall-bladder, and unites at an acute angle with the preceding.

The **ductus communis choledochus** (χολή, bilis; δέχομαι, recipio) is the common excretory duct of the liver and gall-bladder; it is about three inches in length, and is formed by the junction of the hepatic with the cystic duct. It descends through the right border of the lesser omentum, and behind the descending portion of the duodenum to the inner side of that intestine, where it terminates by passing obliquely between the muscular and mucous coat, and opening on the summit of a papilla which is common to it and the pancreatic duct. The papilla is situated near the lower part of the descending portion of the duodenum at its inner side; and the duct is constricted in size during its passage between the coats of the intestine.

Structure of the Bile Ducts.—The largest ducts have an external fibrous coat containing much elastic tissue and a little unstriped muscle; they are lined by columnar epithelium. Those next in size have the same structure, except that there is an absence of the muscular element. The intralobular ducts have simply a basement membrane supporting an epithelium, the cells of which are cubical in their form and almost entirely fill the tube, only a small channel in the centre being left, between the cells the pore-like openings of the biliary capillaries are found. In the main ducts (common bile duct and hepatic duct) numerous racemose mucous glands open on to the surface of the mucous membrane. Those contained in the portal canals have their interior studded by openings which lead into cæcal recesses, some being tubular and others flask-shaped; these are not mucous glands, as was at one time supposed, but simply extensions of the bile ducts, forming receptacles for the retention of the bile.

Vessels and Nerves.—The gall-bladder is supplied with blood by the cystic artery, a branch of the hepatic. Its veins return their blood into the portal vein. The nerves are derived from the hepatic plexus.

THE PANCREAS.

The pancreas is a long, flattened, conglomerate gland, analogous to the salivary glands. It is about six inches in length, and between three and four ounces in weight; is situated transversely across the posterior wall of the abdomen, behind the stomach, and rests on the aorta, vena portæ, inferior vena cava, the origin of the superior mesenteric artery, and the left kidney and supra-renal capsule; opposite the first and second lumbar vertebra. After the abdominal cavity has been laid open, the pancreas may be displayed in one of three ways:—(1) By cutting through the lesser omentum and drawing the stomach downwards; (2) by cutting through the great omentum and displacing the stomach upwards; and (3) by cutting through the transverse meso-colon. A glance at the diagram

of the reflections of peritoneum (fig. 374) will enable the student to understand how the pancreas is reached by each of these incisions.

The pancreas is divided into a body, a greater and a smaller extremity; the great end or head is placed towards the right, and surrounded by the curve of the duodenum; the lesser end or tail extends to the left as far as the spleen. The anterior surface of the body of the pancreas is covered by the ascending posterior layer of peritoneum, and is in relation with the stomach, the first portion of the duodenum, and the commencement of the transverse arch of the colon. The posterior surface is grooved for the splenic vein, and tunnelled by a complete canal for the superior mesenteric and portal vein, and superior mesenteric artery. The upper border presents a deep groove, sometimes a canal, for the splenic artery and vein, and is in relation with the oblique portion of the duodenum, lobus Spigelii, and cœliac axis. And the lower border is separated from the transverse portion of the duodenum by the superior mesenteric artery and vein. On the posterior part of the head of the pancreas is a lobular fold of the gland which completes the canal of the superior mesenteric vessels, and is called the *lesser pancreas*.

The **pancreatic duct** (duct of Wirsung) commences at the small extremity of the organ by two branches, which converge and unite after a course of about one-third the length of the gland. The duct is then continued onwards from left to right, gradually increasing in size, and lying nearer the anterior than the posterior surface of the organ, to the lower part of the descending duodenum, where it terminates on the papilla of mucous membrane, common to it and the ductus communis choledochus. The duct receives numerous branches which open into it on all sides from the lobules of the gland, and at its termination is slightly dilated and passes obliquely between the muscular and mucous coat of the intestine to reach the papilla. The duct which receives the secretion from the lesser pancreas is called the *ductus pancreaticus minor;* it opens into the principal duct near the duodenum, and sometimes passes separately into that intestine. As a variety, two pancreatic ducts are occasionally met with.

In **structure** the pancreas presents the ordinary composition of a *compound racemose gland*, being made up of lobes, and these of reddish-yellow polyhedral lobules, which latter consist of smaller lobules, and the smallest lobules of the ramifications of minute ducts, terminating in *glandular vesicles.* The glandular vesicles are rounded in form (fig. 377), and composed of a *basement membrane*, lined by a *cubical epithelium* of nucleated cells; the cells being somewhat opaque from the presence of fat granules as part of their contents. The *ducts* are composed of areolar and elastic tissue, and lined by a *columnar epithelium.* In the walls of the ducts are numerous small racemose mucous glands like those in the hepatic ducts. The secretion of the pancreas is a clear fluid containing few cells.

Vessels and Nerves.—The arteries of the pancreas are branches of the splenic, hepatic, and superior mesenteric; the *veins* open into the splenic vein; the *lymphatics* terminate in the lumbar glands. The *nerves* are filaments of the splenic plexus.

The pancreas is comparatively larger in the fœtus than in the adult.

THE SPLEEN.

The spleen is an oblong flattened organ, of a dark bluish-red colour, situated in the left hypochondriac region. It is variable in size and weight,* spongy and vascular in texture, and exceedingly friable. The external surface is convex, the internal slightly concave, indented along the middle line, and pierced by several large and irregular openings for the entrance and exit of vessels; this is the *hilum lienis.* The upper extremity is somewhat larger than the lower, and rounded; the inferior is flattened; the posterior border is obtuse, the anterior sharp, and marked by several notches. The spleen is in relation by its external or *convex* surface with the diaphragm, which separates it from the ninth, tenth, and eleventh rib; by its *concave* surface, with the great end of the stomach, small extremity of the pancreas, gastro-splenic omentum with its vessels, left kidney and supra-renal capsule, and left crus of the diaphragm; by its *upper end* with the diaphragm, and sometimes with the extremity of the left lobe of the liver; and, by its *lower end*, with the left extremity of the transverse arch of the colon. It is connected to the stomach by the gastro-splenic omentum, and to the diaphragm by a fold of the peritoneum called the *suspensory ligament.*

A second spleen (lien succenturiatus) is sometimes found appended to one of the branches of the splenic artery, near the great end of the stomach; when it exists, it is round and of small size, rarely larger than a hazel-nut. There are sometimes two, and even three, of these bodies.

Structure.—The spleen is closely invested by the peritoneum, excepting where that membrane is reflected on to the stomach and diaphragm, and at the hilus where the vessels and nerves enter it; this forms its outer or **serous coat.** Beneath this is the proper capsule or **tunica propria**; it is thicker than the serous coat, whitish in appearance, and very elastic. At the hilus the capsule is reflected into the interior of the organ along with the vessels, forming strong bands or **trabeculæ** which radiate from the centre to the circumference, and communicate with each other so as to form a mesh-work enclosing irregular spaces or **areolæ**; the fine external strands of the trabeculæ become connected with the interior of the capsule, binding it firmly and inseparably to the internal structure of the organ. Besides fibrous and elastic tissue these bands contain a few unstriped muscular fibres irregularly distributed. The interspaces or areolæ

* Its ordinary length is about five inches; and its weight six ounces.

thus formed are filled by a soft material of a reddish-brown colour, called the **splenic pulp**; it consists of a fine reticulum of ramified connective-tissue corpuscles (*supporting cells of the pulp*), the interstices of which are occupied by blood containing more than the usual proportion of white corpuscles. The cells of the reticulum contain many pigment granules of a yellow or reddish colour; these are probably derived from disintegrated red blood corpuscles, and, indeed, it is not uncommon to find corpuscles in various stages of change in the protoplasm of the supporting cells. Scattered throughout the spleen numerous light-coloured spots are observed, which, when of large size, present the appearance of sago grains; they are the **Malpighian corpuscles** of the spleen. They are closely connected with the outer coat of the small arterial twigs, sometimes being situated only on one side of the vessel (as shown in fig. 402), but more commonly in the human subject completely surrounding it. In structure they correspond closely to the lymphoid masses described as forming the tonsils, the solitary and agminate glands of the intestine, and the lymph nodules of the lymphatic glands, being composed of retiform tissue supporting innumerable round lymphoid cells. The cells of the retiform tissue are intimately connected with the supporting cells of the pulp. The outer coat of the smaller arteries is throughout the whole of their ramifications in the spleen converted into lymphoid tissue, so that the Malpighian corpuscles are but thicker aggregations of this tissue at certain parts of the course of the vessel.

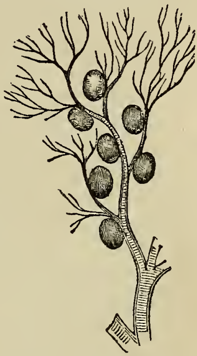

Fig. 402.—Arterial twig of the splenic artery, showing the connection of the splenic corpuscles with the small vessels. From the spleen of the dog.

Arrangement of the Vessels of the Spleen.—The *splenic artery* is of very large size in proportion to the bulk of the spleen; it is a division of the cœliac axis. The branches which enter the spleen are distributed to distinct sections of the organ, and anastomose very sparingly with each other; they terminate in elegant bundles or *pencilli* of minute straight arteries, which end in capillaries. The latter, after running for a short distance, lose their tubular character, and the cells which form their walls become branched and communicate freely with the branched cells of the supporting reticulum of the pulp; the contained blood comes thus to flow directly into the interstices of the latter. The *veins* commence in like manner by capillaries, the cells forming the walls of which are continuous with those of the pulp; as we trace them outwards they assume the tubular character and anastomose freely with each other in the meshes of the trabeculæ, thus differing from the arteries between which, in the substance of the spleen, the anastomoses are few. From this description it will be seen that the

arteries terminate and the veins commence in capillaries which are in direct communication with the pulp, so that the blood, in order to pass from the one to the other, has to traverse it. There are, however, a few arterial capillaries in the trabeculæ and capsule of the spleen which terminate in the veins in the usual manner.

The **lymphatics** of the spleen are in two sets—*trabecular* and *perivascular;* the former run in the trabeculæ and communicate with a superficial set in the capsule; the latter commence in the lymphoid tissue around the arteries and the Malpighian capsules.

The **nerves** form the splenic plexus and are derived from the solar plexus.

THE SUPRA-RENAL CAPSULES.

The supra-renal capsules or *glandulæ supra-renales* are two small yellowish and flattened bodies surmounting the kidneys, and inclining inwards towards the vertebral column. The right is somewhat three-cornered in shape, the left semilunar; they are connected to the kidneys by the common investing areolar tissue, and each capsule is marked on its anterior surface by a fissure or *hilum* which appears to divide it into two lobes. The right supra-renal capsule is closely adherent to the posterior and under surface of the liver, the left lies in contact with the pancreas and spleen. Both capsules rest against the crura of the diaphragm on a level with the tenth dorsal vertebra, and by their inner border are in relation with the great splanchnic nerve and semilunar ganglion. They are larger in the fœtus than in the adult, and appear to be more active during embryonic life. Each capsule is about one and three-quarter inches in height, an inch and a quarter in width, and from two to three lines in thickness; they weigh from one to two drachms.

Structure.—A section of a supra-renal capsule shows that it has externally a fibrous investment or capsule, and internally is divisible into two portions, that nearest the surface and forming the great bulk of the organ being firm, striated, and of a brownish-yellow colour; this is the *cortical portion.* The central or *medullary portion* is of a brownish-black colour, and so soft that many anatomists have erroneously supposed a cavity to exist in it. The **cortical portion** consists of a stroma supporting cells, the cells being arranged in groups, the largest and most important of which assume the appearance of columns. Arnold has divided the cortical portion into three layers. The outer he calls the *zona glomerulosa;* in it the cell groups are round or oval in shape. The next layer he names the *zona fasciculata;* it is much the thickest of the three layers, and forms the bulk of the organ; in it the cells are arranged in columns placed at right angles to the surface of the organ. The third layer of the cortex is a very narrow one called *zona reticularis;* here the stroma is equally distributed, and the cells are consequently not arranged in groups. The cells of the cortex are polyhedral in shape, and consist of granular protoplasm containing oil globules; each

cell has a clear spheroidal nucleus. The **medullary portion** is separated from the cortical by loose areolar tissue; it is traversed by large veins, and is composed of a reticular stroma enclosing groups of cells which differ from those of the cortex in being coarsely granular, devoid of oil globules, and many of them branched. The medulla is rich in nerves, and some observers have supposed the branched cells of this portion of the organ to be nerve cells, Luschka even stating that he has traced nerve fibres in connection with them; this statement is not confirmed by other observers.

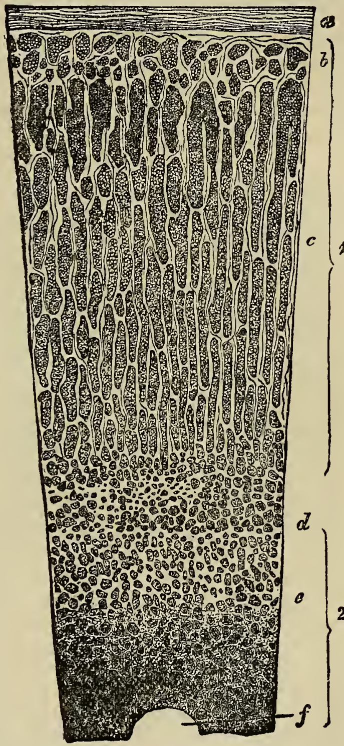

FIG. 403.—Vertical section of supra-renal capsule. 1. Cortex. 2. Medulla. *a.* Capsule. *b.* Zona glomerulosa. *c.* Zona fasciculata. *d.* Zona reticularis. *e.* Medullary substance. *f.* Section of a vein.

The **blood-vessels** of the supra-renal capsules are very numerous. The *arteries*, about twenty in number, proceed from the aorta, phrenic, cœliac, and renal trunks; they enter the cortical substance at every point of its surface, the greater number dividing into minute twigs and forming a plexus in the cortical layer; while others continue onwards to the medullary substance, and either terminate in the medullary plexus or cross the medullary substance to re-enter the cortical layer and contribute to the formation of its capillary plexus. In the cortical substance the capillaries are straight, occupy the intercolumnar spaces, and communicate with each other across the columns by transverse branches, forming oblong meshes; in the medullary substance the capillary plexus is a close network and the meshes rounded. The *veins* take their origin from the capillary plexus by minute venules, which unite to form the supra-renal vein. The *supra-renal vein* runs through the centre of the medullary substance, and issues from the supra-renal capsule at the *hilum* on its anterior surface, to terminate on the right side in the inferior vena cava, on the left in the renal vein. Smaller veins take their course by the side of the arterial twigs, and leave the capsule at various

points of its surface, and terminate in the renal and phrenic veins and inferior vena cava. The *lymphatic vessels* are numerous, and belong to the exterior of the organ; they terminate in the lumbar glands.

The *nerves* are very numerous, and derived from the renal and phrenic plexus; Kölliker counted as many as thirty-three trunks, composed of dark-bordered nerve-fibres and provided with isolated ganglia. They are distributed to the medullary substance only, in which they form a rich nervous plexus.

THE KIDNEYS.

The kidneys, the secreting organs of the urine, are situated in the lumbar regions, behind the peritoneum, and at each side of the vertebral column, extending from the eleventh rib to near the crest of the ilium, and approaching the vertebral column by their upper end. Each kidney is between four and five inches in length, about two inches and a half in breadth, somewhat more than one inch in thickness, and weighs between three and five ounces. The kidneys are usually surrounded by fat; they rest on the crura of the diaphragm, on the anterior lamella of the aponeurosis of the transversalis muscle, which separates them from the quadratus lumborum, and on the psoas magnus. The **right kidney** is somewhat lower than the left, from the position of the liver; it is in relation, by its anterior surface, with the liver and descending portion of the duodenum, which rests against it; and is covered in by the ascending colon. The **left kidney**, higher than the right, is covered, in front, by the great end of the stomach, the spleen, and descending colon. The anterior surface of the kidney is convex, the posterior is flat; the superior extremity is larger than the inferior, and is in relation with the supra-renal capsule; the convex border is turned outwards towards the parietes of the abdomen; the concave border looks inwards towards the vertebral column, and presents a deep notch (*hilum renale*), which leads to a cavity, or *sinus*, within the organ. In the *sinus renalis* are situated the vessels and nerves of the kidney and the expansion of the excretory duct called the **pelvis** of the kidney. At the hilum these vessels are so placed that the renal vein is in front of the artery, and the pelvis and ureter behind.

The kidney is surrounded by a thick layer of fat, contained in the meshes of a loose areolar tissue, and immediately enclosed in a **fibrous capsule**, which is thin, firm, and whitish, and composed of dense areolar tissue intermingled with elastic fibres. The capsule is connected by its inner surface with the substance of the gland by fine areolar tissue, but so loosely as to be easily separable. The substance of the kidney is dense and fragile, and when divided by a longitudinal incision, exhibits two structures, different in colour and texture—an external *vascular* or *cortical portion*, and an internal *tubular* or *medullary portion*. The **medullary portion** consists of from eight to fifteen dark red conical masses, having their apices or **papillæ** directed towards the pelvis, and their bases

to the cortical substance; these conical masses are the **pyramids of Malpighi**, and are composed of an assemblage of **straight tubules**, the *tubuli recti*, which open on the surface of the papilla and divide into branches at acute angles as they proceed from the apex to the base of the pyramid; moreover, the surface of the pyramid is marked by minute vascular streaks caused by the straight vessels of the tubular structure. The **cortical portion**, distinguished by its bright red colour, granular appearance, and softer texture, forms the surface of the organ, surrounding the base of each pyramid and penetrating between them to the sinus renalis. It therefore forms septa between the pyramids (*septa vel columnæ Bertini*), and marks the original composition of the kidney of separate lobes. It is composed of blood-vessels, with the cortical fasciculi and ultimate terminations of the tubuli uriniferi, held together by a delicate stroma of areolar tissue.

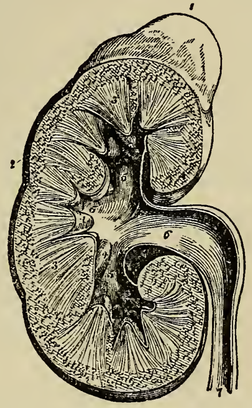

Fig. 404.—Section of the kidney, surmounted by the supra-renal capsule; the swellings on the surface mark the original constitution of the organ of lobes. 1. Supra-renal capsule. 2. Cortical portion of the kidney. 3, 3. Medullary portion, consisting of cones. 4, 4. Two of the papillæ projecting into their corresponding calices. 5, 5, 5. The three infundibula; the middle 5 is situated in the mouth of a calyx. 6. Pelvis. 7. Ureter.

The **tubuli uriniferi** commence on the surface of the papillæ by from two hundred to five hundred openings, and take their course in straight lines, **straight** or **collecting tubules**, through the pyramids, dividing dichotomously in their course and separated by thin long straight blood-vessels. At the base of the pyramids of Malpighi each tubule becomes slightly convoluted, **junctional tubule**, and is continued into a much narrower tube, passing back into the pyramids of the medulla between the straight tubules, and again retracing its course to reach the cortical substance, **looped tubule of Henle.** On reaching the cortex the second time the tubule becomes greatly convoluted, **convoluted tubule**, and finally terminates in a globular expansion called the **Malpighian capsule.** The straight tubules as they pass into the cortex are arranged in groups, the central members of which approach nearest to the surface of the kidney, while the external ones are much shorter and reach only to a short distance from the medulla; they thus form pyramidal masses receiving the name of **pyramids of Ferrein.** The tubes are formed by a basement membrane supporting epithelium; they vary considerably in width in different parts of their course. Near the apex of the papilla, the **excretory tube** (as the canal formed by the union of several straight tubes is often called)

measures from $\frac{1}{240}$ to $\frac{1}{430}$ of an inch; the straight or collecting tubules are smaller, averaging $\frac{1}{600}$ of an inch; the junctional and convoluted portions are about the same size as the straight tubules; the looped tubules of Henle vary from $\frac{1}{1000}$ to $\frac{1}{1200}$ of an inch; and

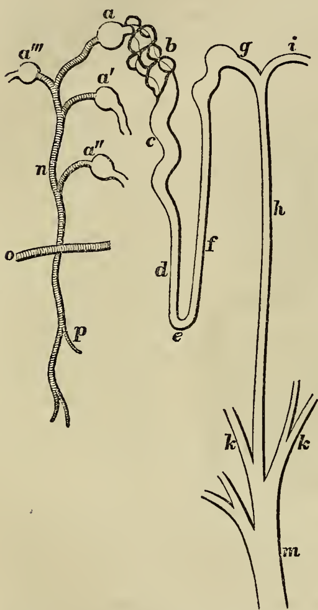

FIG. 405.—Diagram of the uriniferous tubules and interlobular arteries. *m.* Excretory tubule. *k*, *k*. Collecting tubules. *h.* One of the collecting tubes passing into the cortex. *g*, *i*. Junctional tubes. *f.* Ascending limb of tubule of Henle. *e.* Bend, and *d* descending limb. *c.* Convoluted tube. *b.* Plexus of efferent vessels. *a*, *a'*, *a''*, *a'''*. Four Malpighian capsules. *n.* Interlobular artery. *o.* Arterial arch at base of pyramid. *p.* Straight artery (vas rectum).

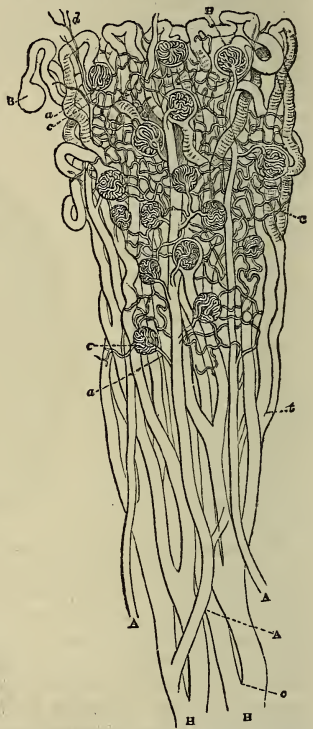

FIG. 406.—Plan of the structure of the kidney. A, A. Primary branches of the renal artery. *a*, *a*. Twigs proceeding to Malpighian bodies. B, B. Malpighian bodies. *c*, *c*. Capillary network, partly formed by efferent vessels from Malpighian bodies, and partly by twigs (*d*) of the renal artery, which do not pass into them. H, H. Larger tubuli uriniferi dividing dichotomously. *t.* A smaller tube.

the Malpighian capsules are from $\frac{1}{120}$ to $\frac{1}{250}$ of an inch in width. The epithelium of the excretory and collecting tubes is columnar, and the lumen is large in proportion to the depth of the cells. In the convoluted tubes the epithelium is granular, the nucleus indis-

tinct, and the lumen comparatively small, the space left being only about one-third the total diameter of the tube; the cells are separated at their free borders by distinct fissures or clefts extending down to the basement membrane. A difference exists in the appearance presented by the ascending and descending limb of the looped tubules of Henle; in the latter the lumen is distinct, and the cells form a flattened layer thickened here and there by the presence of nuclei; in the former the cells approximate in character to those of the convoluted tube, and although the whole tube is wider than the descending limb the lumen is much narrower.

The Malpighian capsule encloses a vascular tuft called the **glomerulus**, the tuft and capsule together constituting the **Malpighian body.** These little spheroidal bodies are found only in the cortical substance of the kidney, and form the most distinctive feature of the structure of the organ. Two vessels are connected with each Malpighian body, one entering it, **afferent vessel**, and the other leaving it, **efferent vessel**; the glomerulus and its vessels resemble in appearance fruit supported on its stalk. The capsule is lined by a flattened epithelium, which may also be traced on to the surface of the glomerulus, being most distinct in the latter situation where the capsule opens into the convoluted tube. The epithelial cells both in the uriniferous tube and capsule are supported by a basement membrane formed of flattened epithelial cells.

Blood-vessels.—The **renal artery**, derived from the aorta, enters the kidney between the vein and ureter, and divides into four or five

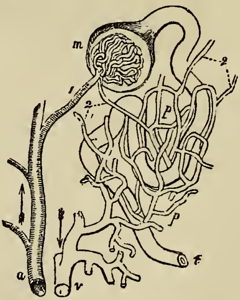

FIG. 407.—Plan of the renal circulation. *a.* Interlobular branch of the renal artery giving off several afferent vessels. 1. An afferent twig to the capillary tuft contained in the Malpighian body, *m*; from the Malpighian body the uriniferous tube is seen taking its tortuous course to *t*. 2, 2. Efferent vessels; that which proceeds from the Malpighian body is smaller than the corresponding artery. *p*, *p*. The capillary plexus, ramifying on the uriniferous tube. This plexus receives its blood from the efferent vessels, 2, 2; and transmits it to the branch of the renal vein, *v*.

large trunks which pass between the papillæ to enter that portion of the cortical substance placed between the pyramids of the medulla; here they divide and subdivide, and give off small branches, which communicate across the bases of the pyramids so as to form imperfect arches between the cortical and medullary substance. From these arches are given off **interlobular arteries**, placed between the pyramids of Ferrein, and giving off afferent vessels on each side to the Malpighian bodies. In the Malpighian body the afferent artery divides into from five to eight branches, and each of these branches into a bundle of capillaries, and the latter, reuniting in the same

manner, constitute the *efferent vessel.* The *efferent vessel*, quitting the Malpighian body by the side of the afferent artery, divides into capillary vessels, which form a rich capillary plexus throughout the whole of the cortical substance, and eventually terminate in the renal veins. Those efferent vessels which are nearest to the base of the pyramids take a straight course (*arteriolæ rectæ*) between the tubuli recti, and giving off but few branches in their course, also pass into a capillary plexus which surrounds the tubuli and terminates in the *venulæ rectæ.* The renal artery also gives off branches to the capsule of the kidney which anastomose freely with branches of the lumbar arteries.

The **veins** of the kidney commence at the surface by minute converging venules, the **stellated vessels**, in the cortical substance where they form the **interlobular veins**, and in the pyramids of Malpighi, where they constitute the **venulæ rectæ**; proceeding from these three sources, they unite to form the branches of the renal vein, which terminates in the vena cava by a single large trunk at each side; the left renal vein receiving the left spermatic vein. Injections thrown into the renal artery, and returning by the tubuli uriniferi, make their way into those tubes by rupture. The **lymphatic vessels** accompany the deep blood-vessels, and terminate in the lumbar glands.

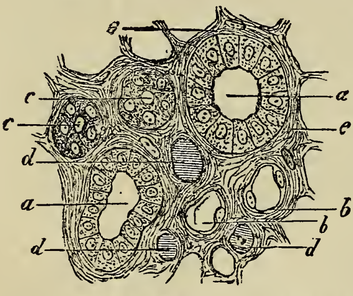

FIG. 408.—Transverse section through a Malpighian pyramid. *a, a.* Collecting tubule with columnar epithelium. *b, b.* Descending limb of looped tubule of Henle, lined by flat cells. *c, c.* Ascending limb with thick granular cells. *d, d.* Transverse section of vessels. *e, e.* Intertubular stroma.

The **nerves** are derived from the renal plexus, which is formed partly by the solar plexus, and partly by the third splanchnic nerve. The renal plexus gives branches to the spermatic plexus, and branches which accompany the ureters: hence the morbid sympathies which exist between the kidney, ureter, and testicle; and by communications with the solar plexus, with the stomach and diaphragm, and indeed with the whole system.

Intertubular Stroma.—The tubules and vessels of the kidney are held together and supported by very fine connective tissue, that in the neighbourhood of the vessels and around the Malpighian bodies being fibrous in its character. The stroma is more abundant in the cortical than in the medullary portion, and is there chiefly formed of connective-tissue corpuscles.

The **cavity of the kidney** is occupied by a membranous bag, the **pelvis renalis**, which gives off three processes, the **infundibula**, one for each extremity, and one for the middle of the organ; and the infundibula give off smaller processes termed **calices**, which

embrace the papillæ and form a separate pouch around each; the calyx being firmly attached to the base of the papilla and continuous with the fibrous capsule. Externally the sac of the pelvis renalis contracts into its excretory duct, the ureter.

Ureter.

The ureter (*οὐρέω*, I pass water) is a membranous tube of about the diameter of a goose-quill, and nearly eighteen inches in length, continuous superiorly with the pelvis of the kidney, and constricted inferiorly, where it lies in an oblique direction between the muscular and mucous coat of the base of the bladder, and opens on its mucous surface. Lying along the posterior wall of the abdomen, it is situated behind the peritoneum, and is crossed by the spermatic vessels; in its course downwards it rests against the anterior surface of the psoas, and crosses the common iliac artery and vein, and then the external iliac vessels. Within the pelvis it crosses the hypogastric cord and vas deferens in the male; and runs by the side of the cervix uteri and upper part of the vagina in the female. There are sometimes two ureters to one kidney. The ureter, the pelvis, the infundibula, and the calices are composed of three coats, external or fibrous, middle or muscular, and internal or mucous. The **fibrous coat** consists of condensed areolar tissue, intermingled with fine elastic fibres. The **muscular coat** is made up of muscular fibres of the smooth kind, disposed in two layers, external longitudinal, and internal circular; while towards the bladder there are besides internal longitudinal fibres. The muscular coat is thick in the ureter and pelvis renalis, thin on the calices, and ceases altogether at the attachment of the latter to the papillæ. The **mucous coat** is thin, vascular, and without villi; on the papillæ it is connected with the substance of the pyramids, and is continuous with the uriniferous tubuli, while inferiorly it becomes blended with the mucous membrane of the bladder. The *epithelium* of the mucous coat is thick, and composed of several layers of nucleated cells, which are small and round next the membrane; of larger size and cylindrical or pear-shaped in the middle; and large and cubical at the surface, sometimes measuring $\frac{1}{600}$ of an inch in breadth, and not unfrequently containing two nuclei. Many of the superficial cubical cells are excavated on their under surface into little depressions, into which the heads of the pear-shaped cells of the middle layer fit.

PELVIS.

The cavity of the pelvis is that portion of the great abdominal cavity which is included within the bones of the pelvis, below the level of the pectineal line and promontory of the sacrum. It is bounded by the cavity of the abdomen above, and by the perineum below; its internal parietes are formed in front, below, and at the sides, by the peritoneum, pelvic fascia, levatores ani, and obturator

muscles; and behind, by the coccygei muscles, sacro-ischiatic ligaments, pyriformes muscles, sacral plexus of nerves, sacrum, and coccyx.

The **viscera of the pelvis** in the male are—the urinary bladder, prostate gland, vesiculæ seminales, and rectum.

URINARY BLADDER.

The bladder is a hollow membranous viscus, triangular and flattened against the pubes when empty, ovoid when distended, situated behind the pubes and in front of and upon the rectum. It is larger in its vertical diameter than from side to side; and its long axis is directed from above, obliquely downwards and backwards. It is divided into body, fundus, base, and neck. The **body** comprehends the middle zone of the organ; the **summit** or **superior fundus**, its upper segment; the **base** or **inferior fundus**, the lower broad extremity which rests on the rectum; and the **neck**, the narrow constricted portion which is applied against the prostate gland.

It is retained in position by ligaments which are divisible into true and false: the **true ligaments** are five in number, two anterior, two lateral, and the cord of the urachus; the **false ligaments** are folds of the peritoneum, and are also five in number, two posterior, two lateral, and one superior.

The **anterior ligaments** are formed by the recto-vesical fascia in its passage from the inner surface of the pubes at each side of the symphysis to the neck of the bladder and prostate gland.

The **lateral ligaments** are also formed by the recto-vesical fascia in its passage from the levatores ani muscles to the sides of the prostate gland and neck of the bladder.

The **ligament of the urachus** is a fibrous cord resulting from the obliteration of a tubular canal (urachus) existing in the embryo. It proceeds from the summit of the bladder, and ascends along the linea alba to the umbilicus.

The **posterior false ligaments** are the folds of peritoneum formed at each side of the pelvis by the obliterated hypogastric artery; these folds also contain the ureters, and the vessels and nerves of the bladder.

The **lateral false ligaments** are formed by the passage of the peritoneum from the side of the pelvis to the side of the bladder. The obliterated hypogastric artery lies along the line of reflection of the membrane.

The **superior** or **suspensory false ligament** is the fold of peritoneum caused by the prominence of the cord of the urachus and the cords of the obliterated hypogastric arteries.

Structure.—The bladder is composed of four coats, external or serous, muscular, areolar, and mucous.

The **serous coat** is partial, and derived from the peritoneum; it invests the posterior surface and sides of the bladder, from about

opposite the point of termination of the ureters to its summit, whence it is guided to the anterior wall of the abdomen by the hypogastric cords and urachus.

The **muscular coat** consists of three layers, external or longitudinal, middle or circular, and internal, which is also longitudinal. The **external layer,** or **detrusor urinæ,** consists of parallel longitudinal fasciculi which take their origin from the anterior ligaments of the bladder, thence named tendons of the detrusor urinæ; they spread out upon the upper surface of the prostate gland and ascend upon the anterior surface of the bladder to the fundus, where they are inserted into the subserous tissue, some being continuous with the longitudinal fibres of the posterior surface of the organ, and others prolonged upon the urachus. The longitudinal fasciculi of the posterior surface and sides of the bladder, attached superiorly to the subserous tissue, and partly continuous with those of the opposite aspect, while some are prolonged upon the urachus, are attached inferiorly to the prostate gland, those in the middle line being lost in the deep muscular layer of the neck of the bladder. The detrusor urinæ is thickest on the anterior surface of the bladder; it communicates by an interchange of fasciculi with the middle layer, and in the female its posterior fibres are inserted into the vagina. The **middle layer** consists of circular fibres which are most numerous at the cervix, where they form a moderately thick stratum, the **sphincter vesicæ,** and are then continued onwards around the prostatic urethra. The **internal layer** (submucous layer; Ellis), thinner than the preceding, is composed of fibres which are oblique and scattered in the fundus and body of the bladder, but become longitudinal in its lower part and base, and are continued through the cervix and along the urethra to its termination at the meatus urinarius. At the base of the bladder this layer is strengthened by the longitudinal fibres of the ureters, which, after perforating the external and middle muscular layer, spread out in a radiated manner and are continuous with the internal longitudinal layer, the increment of fibres in this situation constituting the *muscles of the ureters.* The three muscular layers communicate with each other by means of a frequent interchange of fasciculi, and are thus enabled to act in unison as a single muscle. In the trigone the radiating fibres of the ureters have a transverse direction, and the muscular structure is intermingled with areolar and elastic tissue.

The **areolar** or submucous coat is the thick layer of areolar tissue interposed between the mucous and muscular coat, and forming the bond of union between them.

The **mucous coat** is thick and smooth, of a pale-rose colour, and exactly moulded on the muscular coat, to which it is connected by the areolar coat; it has no papillæ, but numerous mucous glands which are most abundant in the cervix and fundus, and are either simple pyriform follicles or small aggregations of follicles constituting racemose glands. The mucous membrane is continuous through the ureters with the lining membrane of the uriniferous

ducts, and through the urethra with that of the seminiferous ducts, prostate gland, and Cowper's glands. It is provided with a laminated epithelium, the deeper cells of which are conical or fusiform; the superficial, spheroidal or flattened, and of unequal size. In the mucous glands the epithelium is columnar. The mucous membrane is rich in vessels, which are most abundant, as are the nerves, in the cervix and fundus; the nerves are not numerous.

On the internal surface of the base of the bladder is a triangular smooth plane, the **trigonum vesicæ** or vesical trigone (fig. 414), on

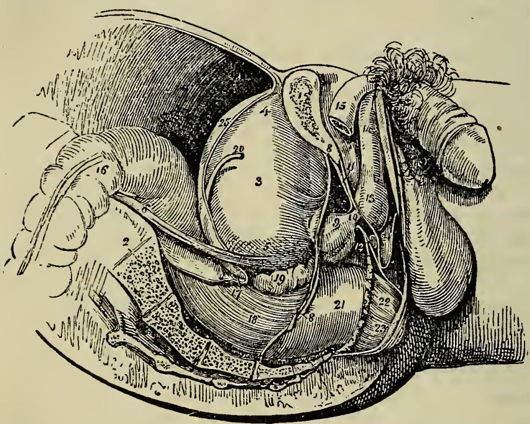

Fig. 409. — Side view of the viscera of the male pelvis, *in situ*. The right side of the pelvis has been removed by a vertical section made through the os pubis near the symphysis; and another through the middle of the sacrum. 1. Divided surface of the os pubis. 2. Divided surface of the sacrum. 3. Body of the bladder. 4. Its superior fundus; from the apex is seen passing upwards the urachus. 5. Base of the bladder. 6. Ureter. 7. Neck of the bladder. 8, 8. Pelvic fascia; the fibres immediately above 7, are given off from the pelvic fascia, and represent the anterior ligaments of the bladder. 9. Prostate gland. 10. Membranous portion of the urethra. 11. Triangular ligament. 12. One of Cowper's glands lying beneath the membranous portion of the urethra. 13. Bulb of corpus spongiosum. 14. Body of corpus spongiosum. 15. Right crus penis. 16. Upper part of first portion of the rectum. 17. Recto-vesical fold of peritoneum. 18. Second portion of rectum. 19. Right vesicula seminalis. 20. Vas deferens. 21. The rectum covered by the descending layer of the pelvic fascia, just as it is making its bend backwards to constitute the third portion. 22. Part of the levator ani muscle investing the lower part of the rectum. 23. External sphincter ani. 24. Interval between the superficial perineal fascia and triangular ligament; they are seen to be continuous beneath the figure.

which the mucous membrane is paler and thinner than the rest. Calculi resting on this part give rise to much suffering on account of the greater number of nerves distributed to the cervix vesicæ. The trigone is bounded at each side by the raised ridge, corresponding with the muscles of the ureters, at each posterior angle by the openings of the ureters, and, in front, by a slight elevation of the mucous membrane at the entrance of the urethra, called *uvula vesicæ*.

The external surface of the base of the bladder corresponding with the trigone is also triangular, and separated from the rectum by a

thin layer of areolo-fibrous membrane derived from the recto-vesical fascia. It is bounded behind by the recto-vesical fold of peritoneum and at each side by the vas deferens and vesicula seminalis, which converge almost to a point at the base of the prostate gland. It is through this space that the opening is made in the recto-vesical operation for puncture of the bladder.

Vessels and Nerves.—The *arteries* of the urinary bladder are the *superior vesical*, three or four small branches which proceed from the commencement of the hypogastric artery, previously to its complete obliteration; an *inferior vesical*, from the internal iliac. The latter is distributed to the base of the bladder, vesiculæ seminales, and prostate gland. The *veins* are numerous and of large size, and form a plexus around the neck and at the base of the bladder; the plexus communicates with the prostatic plexus and hæmorrhoidal veins. The *nerves* of the bladder are derived from the inferior hypogastric plexuses and their communications with the third and fourth sacral nerves.

PROSTATE GLAND.

The prostate gland (προΐστημι, præponere) is situated in front of the neck of the bladder, behind the triangular ligament and pelvic fascia, and upon the rectum, through which latter it may be felt with the finger. It measures about one and a half inches across at its base, its width is about an inch and a quarter, and its depth nearly an inch; it weighs from six drachms to an ounce. It surrounds the commencement of the urethra for a little more than an inch of its extent, and resembles a Spanish chestnut both in size and form; the base being directed backwards towards the neck of the bladder, the apex forwards, and the flattened side towards the rectum. It is retained firmly in position by the anterior and lateral ligaments of the bladder, and by a process of the recto-vesical fascia, which forms a sheath around it. It consists of three lobes, two lateral and a middle lobe or isthmus; the lateral lobes are distinguished by an indentation at the base of the gland, and a slight furrow on its upper and lower surface. The third lobe or isthmus is a small transverse band which passes between the two lateral lobes at the back part of the under surface of the organ; it is generally imperfectly marked in the normal state of the gland, but becomes evident when enlarged; when prominent it corresponds to the elevation at the neck of the bladder called the *uvula*.

Structure.—In structure the prostate is composed of smooth muscle and glandular tissue, the latter being not more than one-third or one-fourth of the whole, and consisting of from thirty to fifty compound racemose glands, of a pyriform shape. It is of a greyish-red colour and dense in texture, splits easily in the course of its ducts, and is surrounded by a proper fibrous covering, and by a plexus of veins enclosed in a sheath derived from the recto-vesical fascia. Its secretion is poured into the prostatic portion of the

urethra by fifteen or twenty excretory ducts. The ducts of the lateral lobes open into the urethra at each side of the veru montanum; those of the third lobe open upon and behind the veru. The urethra, in passing through the prostate, lies one-third nearer its upper, than its lower, surface.

The **arteries** of the prostate are small and derived from the inferior vesical and middle hæmorrhoidal; they distribute numerous capillaries to the glandular structure of the organ. The **veins** form a rich plexus in the submucous tissue of the urethra, and another of larger vessels on the exterior of the gland; the latter receives from the front the veins of the penis, and terminates in the vesical plexus.

VESICULÆ SEMINALES.

On the under surface of the base of the bladder, and converging towards the base of the prostate gland, are two lobulated and somewhat pyriform bodies, about two inches in length, the vesiculæ seminales. Their upper surface is in contact with the base of the bladder; the under side rests on the rectum, separated only by the recto-vesical fascia; the larger extremities are directed backwards and outwards, and the smaller ends almost meet at the base of the prostate. They enclose between them a triangular space, which is bounded posteriorly by the recto-vesical fold of peritoneum, and corresponds with the trigonum vesicæ on the interior of the bladder. Each vesicula is formed by the convolutions of a single tube, which gives off several irregular cæcal sacculi and branches. It is enclosed in a thin fibrous membrane, and is constricted beneath the isthmus of the prostate gland into a small excretory duct. The **vas deferens**, somewhat enlarged and sacculated, lies along the inner border of each vesicula, and is included in its fibrous investment. It communicates with the duct of the vesicula beneath the isthmus of the prostate, and forms the ejaculatory duct.

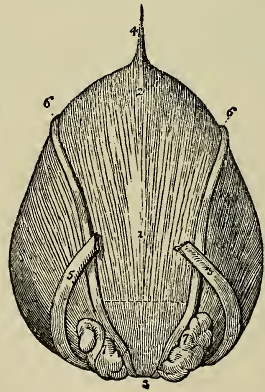

Fig. 410.—Posterior aspect of the male bladder; the serous covering is removed in order to show the muscular coat. 1. Body of the bladder. 2. Superior fundus. 3. Inferior fundus or base. 4. Urachus. 5, 5. Ureters. 6, 6. Vasa deferentia. 7, 7. Vesiculæ seminales. The triangular area, bounded by the vasa deferentia and vesiculæ seminales at either side, a dotted line above, and the figure 3 below, is the space corresponding with the trigonum vesicæ. The dotted line, forming the base of this triangular area, marks the extent of the recto-vesical fold of peritoneum.

The **ejaculatory duct** is about three-quarters of an inch in length, and running forwards, first between the base of the prostate and the isthmus, and then through the tissue of the veru montanum,

PLATE 26.

THE MALE PERINEUM.

Fig. 1.—The Accelerator Urinæ Removed to show the Bulb of the Urethra, and the Triangular Ligament partially Removed to show Cowper's Glands.

Fig. 2.—The Levator Ani Removed, and Rectum turned down to show the Prostate and Neck of Bladder.

A. Urethra.
B. Bulb.
C. Prostate.
D. Crus penis with erector.
E. Triangular ligament (cut to show Cowper's glands).
F. Anus.
G. Tuber ischii.
H. Coccyx.
I. Gluteus maximus.
K. Levator ani.
L. Pudic artery.
M. Membranous urethra.
N. Vesicula seminalis.
O. Sacro-sciatic ligament.
P. Base of bladder.
Q. Vas deferens.

PLATE 26.

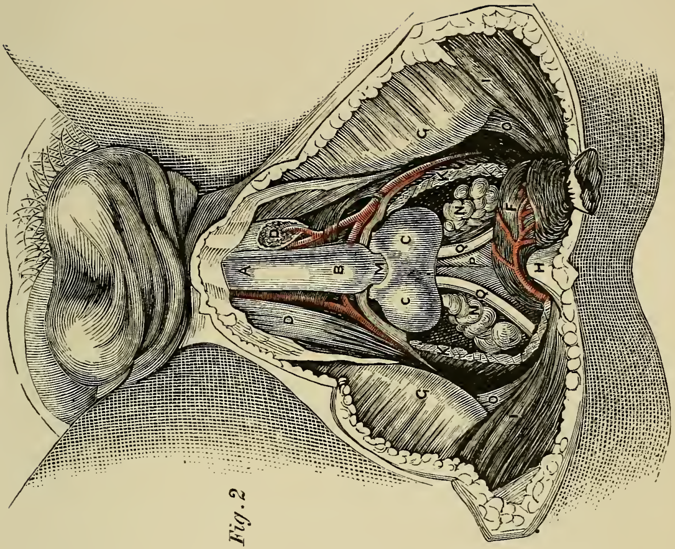

Fig. 2

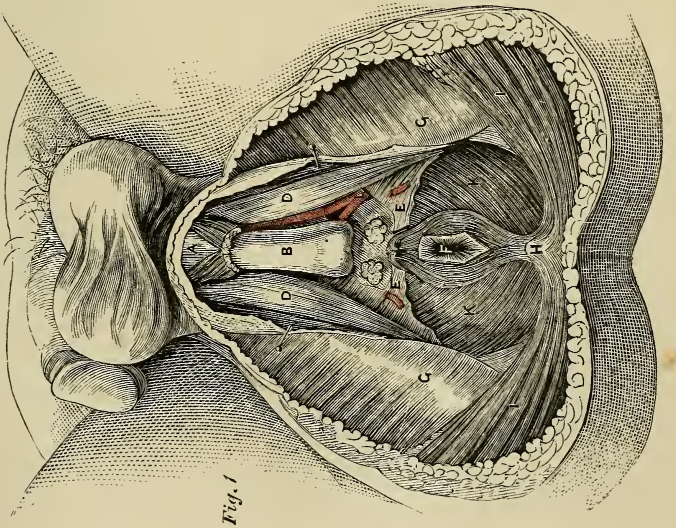

Fig. 1

opens on the mucous membrane of the urethra, by the side of or within the aperture of the sinus pocularis.

The vesiculæ seminales and vasa deferentia are partly covered in by a muscular layer, *compressor vesiculæ et ductus seminalis* (Ellis); which is brought into view on raising the recto-vesical fascia. This muscular layer consists of transverse and longitudinal fibres, the *transverse fibres* being the most superficial, and continuous with the posterior border of the prostate gland; the *longitudinal fibres* lying in contact with the vesiculæ and vasa deferentia. The longitudinal fibres form a continuous fleshy plane for the space of half an inch behind the prostate, and are prolonged for a short distance backwards on the vesiculæ and vasa deferentia, lying chiefly along their borders; while, anteriorly, the fibres accompany the ejaculatory ducts to the termination of the latter in the urethra, and are continuous with the internal longitudinal coat of the prostatic urethra.

In **structure** the vesiculæ seminales are composed of three coats: *external*, a thin **fibrous** membrane, made up of condensed areolar tissue; *middle*, a **muscular** coat, consisting of smooth muscular fibres arranged in two layers, longitudinal and circular; and *internal*, a thin **mucous** membrane, vascular, marked by a delicate reticulation of ridges and alveoli, and coated with a squamous epithelium of cells containing yellowish pigment granules. Opening on to the surface of the mucous membrane are a large number of tubular glands, which give to its surface a brownish-yellow colour. The vesiculæ are covered externally and their convolutions held together by a thin membrane of areolar tissue, and they are further invested by the recto-vesical fascia, and the muscular stratum already described.

MALE ORGANS OF GENERATION.

The organs of generation in the male are—the penis and testicles, with their appendages.

PENIS.

The penis is divisible into a body, root, and extremity. The **body** is surrounded by a thin integument, which is remarkable for the looseness of its connection with the deeper parts of the organ, and for containing no adipose tissue. The **root** is broad, and firmly adherent to the rami of the pubes and ischium by means of two strong processes, the **crura**, and connected to the symphysis pubis by an elastic fibrous membrane, the **suspensory ligament.** The *extremity* or **glans penis** resembles an obtuse cone, somewhat compressed from above downwards, and of a deeper red colour than the surrounding skin. At its apex is a small vertical slit, the **meatus urinarius**, which is bounded by two, more or less protuberant, labia; and, extending backwards from the meatus, a grooved raphé, to which a loose fold of mucous membrane, the **frænum præputii**, is attached. The base of the glans is marked by a projecting collar,

the **corona glandis**, upon which are seen a number of small papillary elevations, the **glandulæ odoriferæ** Tysoni. Behind the corona is a deep fossa, **fossa glandis** (cervix), bounded by a circular fold of integument, **prepuce**, which, in the collapsed state of the organ, may be drawn over the glans, but, in its distended state, is obliterated, and serves to facilitate its enlargement. The internal surface of the prepuce is lined by mucous membrane, covered by a thin epithelium; this membrane, on reaching the cervix glandis, is reflected over the glans, and, at the meatus urinarius, is continuous with the mucous lining of the urethra. The mucous membrane over the glans is devoid of glands, is very firmly adherent to subjacent structures, and is studded over with a number of very fine papillæ; it is very vascular, and extremely sensitive.

The **superficial fascia** of the penis is thin, and its areolar structure free from fat; it is continuous with the superficial fascia of the abdomen above, and with the dartos and superficial fascia of the perineum below.

The **suspensory ligament** of the penis is an elastic fibrous membrane of triangular form, attached by its apex to the symphysis pubis; and by its base, to the body of the penis. Near the latter attachment it separates into two layers, to give passage to the dorsal vessels and nerves of the penis.

The penis is composed of the *corpus cavernosum* and *corpus spongiosum*, and contains in its interior the longest portion of the urethra.

The **corpus cavernosum** is distinguished into two lateral portions (corpora cavernosa) by an imperfect septum and a superior and inferior groove, and is divided posteriorly into two crura. It is firmly adherent, by means of its crura, to the rami of the pubes and ischium; and each crus, previously to its junction with its fellow, presents a slight enlargement, which was named by Kobelt, the **bulb.** The corpus cavernosum forms, anteriorly, a single rounded extremity, which is received into a fossa in the base of the glans; the superior groove lodges the dorsal vessels of the penis, and the inferior receives the corpus spongiosum. Its fibrous tunic is thick, elastic, and extremely firm, and sends a number of fibrous bands and cords (trabeculæ) inwards from the inferior groove, which cross the interior in a radiating direction, and are inserted into the inner walls of the tunic. These trabeculæ are most abundant at the middle line, where they are ranged vertically, side by side, somewhat like the teeth of a comb, and constitute the imperfect partition of the corpus cavernosum, called **septum pectiniforme.** The septum is more complete at its posterior than towards its anterior part.

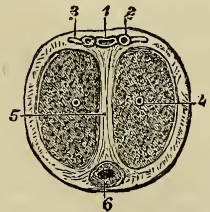

FIG. 411.—Transverse section of the penis. 1. Dorsal vein. 2. Dorsal artery. 3. Dorsal nerve. 4. Artery of corpus cavernosum. 5. Septum pectiniforme. 6. Urethra, surrounded by corpus spongiosum.

The tunic of the corpus cavernosum consists of two layers of fibrous fasciculi: the *external* being longitudinal and forming a kind of close net by the frequent interchange of their fibrous bundles; the *internal*, less thick, being disposed in a circular direction, and constituting the septum pectiniforme. From its anterior extremity it gives off small fibrous bands, which are prolonged into the substance of the glans penis. The cavity of the corpus cavernosum is occupied by the spongy mass of its erectile tissue.

The **corpus spongiosum** is situated along the under surface of the corpus cavernosum, in its inferior groove. It commences by its posterior extremity between and beneath the crura penis, where it forms an enlargement, the **bulb**, and terminates anteriorly by another expansion, the **glans penis.** Its middle portion, or body, is nearly cylindrical, and tapers gradually from the posterior to the anterior extremity. The bulb is adherent to the triangular ligament by means of a prolongation of fibrous membrane; in the rest of its extent the corpus spongiosum is attached to the corpus cavernosum by areolar tissue, and by veins which pass upwards to reach the dorsal vein. It is composed of erectile tissue, enclosed in a dense fibrous layer much thinner than that of the corpus cavernosum, and contains the spongy portion of the urethra, which lies nearer its upper than its lower wall. The bulb shows a tendency to division into two lobes, an appearance which is due to the existence of a thin longitudinal septum in its interior.

The fibrous tunic of the corpus spongiosum, unlike that of the corpus cavernosum, consists only of circular fibres which are reflected inwards along the middle line, forming a septum which is complete only in the bulb; the reflected fibres of this septum embrace the urethra through its entire length, and exclude the latter from the proper structure of the corpus spongiosum.

Erectile tissue is a peculiar cellulo-vascular structure, entering in considerable quantity into the composition of the organs of generation. It consists of bands of fibrous and elastic tissue (with a few muscular fibres) which pass from the capsule of the organ into its interior, and there divide and unite in such a manner as to produce a system of cavities communicating freely with each other. The cavities are smaller in the glans penis, corpus spongiosum, and circumference of the corpus cavernosum than in the central part of the latter, where they are large and dilated; they are lined by a layer of flattened epithelial cells, continuous with those lining the arteries and veins. The cavernous spaces are at all times filled with blood, but become overcharged and distended during erection of the organ, in consequence of pressure upon its large veins retarding the venous flow. The arteries are convoluted in the passive state of the penis, but straightened in its distended condition; they terminate in large capillaries, which do not form a plexus, as in other situations, but open directly into these dilated veins. Some of the finer twigs of the arteries have a peculiar, twisted, and dilated or tendril-like appearance, first described by Müller under the name of *arteriæ*

helicinæ. The helicine arteries were supposed by Müller to end by cæcal terminations; but Kölliker finds a minute artery to proceed from the bulbous extremity of each of these dilated vessels, and terminate like the other capillaries in the veins. Arnold regards the helicine arteries as mere vascular loops. The venous plexus conveys the blood into the efferent veins of the penis, by which it is returned to the general circulation.

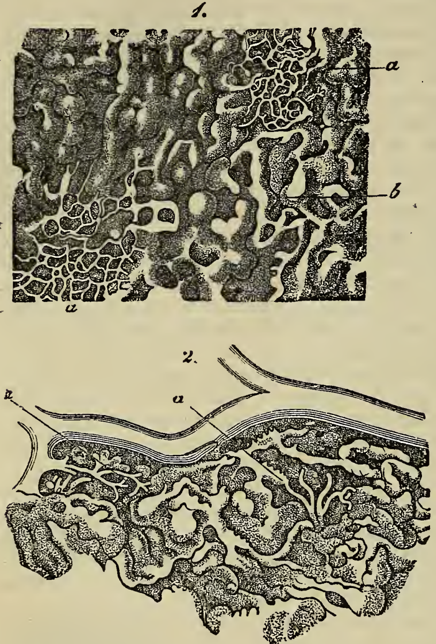

FIG. 412.—Structure of the peripheral portion of the corpus cavernosum penis. 1, *a*, *a*. Superficial network. *b*. Deep network. 2. Connection of the arterial twigs (*a*, *a*) with the canals of the deeper cortical network.

Vessels and Nerves.—The arteries of the penis are derived from the internal pudic; they are—the arteries of the bulb, arteries of the corpus cavernosum, and dorsales penis. Its *veins* are superficial and deep. The deep veins run by the side of the deep arteries, and terminate in the internal pudic veins. The superficial veins escape in considerable number from the base of the glans, and converge on the dorsum penis, to form a large dorsal vein, which receives other veins from the corpus cavernosum and spongiosum in its course, and passes backwards between two layers of the ligamentum suspensorium, and through the triangular ligament beneath the arch of the pubes, to terminate in the prostatic plexus.

The **lymphatics** terminate in the upper group of inguinal glands, while some of the deeper lymphatics take the course of the urethra and end in the pelvic glands. The *nerves* are derived from the pudic nerve, sacral plexus, and hypogastric plexus.

URETHRA.

The urethra is the membranous canal extending from the neck of the bladder to the meatus urinarius. It is curved in its course, and composed of three layers, a mucous coat, submucous coat, and

muscular coat. The **mucous coat** is thin and smooth; it is continuous internally with the mucous membrane of the bladder; externally, with the investing membrane of the glans; and at certain points of its extent, with the lining membrane of the numerous ducts which open into the urethra, namely, those of Cowper's glands, prostate gland, vasa deferentia, and vesiculæ

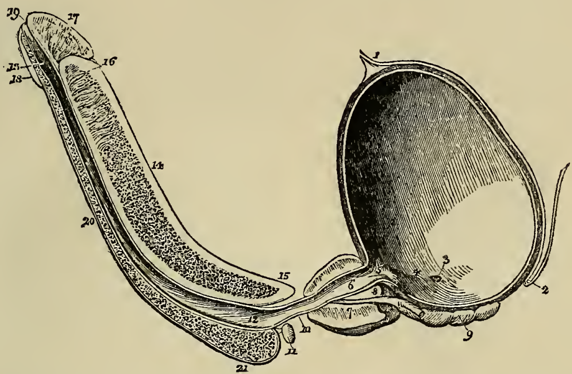

FIG. 413.—Longitudinal section of the bladder, prostate gland, and penis, showing the urethra. 1. Urachus attached to the upper part of the bladder. 2. Recto-vesical fold of peritoneum, at its point of reflection from the base of the bladder, upon the anterior surface of the rectum. 3. Opening of the right ureter. 4. A slight ridge, formed by the muscle of the ureter, and extending from the termination of the ureter to the commencement of the urethra. This ridge forms the lateral boundary of the trigonum vesicæ. 5. Commencement of the urethra; the elevation of mucous membrane immediately below the figure is the uvula vesicæ. The constriction of the bladder at this point is the neck of the bladder. 6. Prostatic portion of the urethra. 7. Prostate gland; the difference of thickness of the gland above and below the urethra is shown. 8. Isthmus, or third lobe of the prostate, immediately beneath which the ejaculatory duct is seen passing. 9. Right vesicula seminalis; the vas deferens is seen to be cut short off, close to its junction with the ejaculatory duct. 10. Membranous portion of the urethra. 11. Cowper's gland of the right side, with its duct. 12. Bulbous portion of the urethra; throughout the whole length of the urethra of the corpus spongiosum numerous lacunæ are seen. 13. Fossa navicularis. 14. Corpus cavernosum, cut somewhat obliquely to the right side, near its lower part. 15. Right crus penis. 16. Near the upper part of the corpus cavernosum, the section has fallen a little to the left of the middle line; a portion of the septum pectiniforme is consequently seen. This figure also indicates the thickness of the fibrous investment of the corpus cavernosum, and its abrupt termination at the base of (17) the glans penis. 18. Lower segment of the glans. 19. Meatus urinarius. 20. Corpus spongiosum. 21. Bulb of the corpus spongiosum.

seminales. It is provided with a stratified squamous epithelium corresponding with that of the bladder, and has opening on to its surface numerous mucous recesses or crypts, and the ducts of the glands lying in the submucous tissue. The **submucous coat** is loose, and contains a convoluted vascular structure resembling erectile tissue; it also contains numerous racemose mucous glands, which

open on the surface of the mucous membrane (*glands of Littré*). The glands are most abundant along the floor of the urethra, especially in the bulbous portion. The **muscular coat** consists of circular fibres, intermingled with areolar and elastic tissue, and is continuous with the circular muscular layer of the bladder.

The urethra is about eight inches in length, and divided into a prostatic, membranous, and spongy portion.

The **prostatic portion**, a little more than an inch in length, is situated in the prostate gland, about one-third nearer its upper than its lower surface, and extending from its base to its apex. On its lower circumference or floor is a longitudinal ridge or crest, the **veru montanum**, or **caput gallinaginis**; and at each side of the

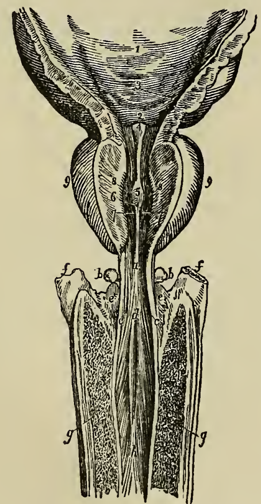

Fig. 414.—The bulbous, membranous, and prostatic urethra, with part of the bladder. 1. Part of the urinary bladder: its internal surface. 2. Trigonum vesicæ. 3. Openings of the ureters. 4. Uvula vesicæ. 5. Veru montanum. 6. Opening of the sinus pocularis. 7, 7. Apertures of the ejaculatory ducts. 8, 8. Openings of the prostatic ducts. The figures 7, 7, and 8, 8, are placed on the cut surface of the supra-urethral portion of the prostate gland. 9, 9. Lateral lobes of the prostate gland. *a*. Membranous portion of the urethra. *b*, *b*. Cowper's gland. *c*, *c*. Apertures of the excretory ducts of Cowper's glands. *d*. Commencement of the bulbous portion of the urethra. *e*, *e*. Upper surface of the bulb of the corpus spongiosum. *f*, *f*. Crura penis. *g*, *g*. Corpus cavernosum. *h*. Spongy portion of the urethra.

veru, a shallow fossa, the **prostatic sinus**, in which are seen the numerous openings (15 to 20) of the prostatic ducts.

The veru montanum is most prominent in the centre; and immediately in front of the prominent part is the opening of a small cæcal sac, the **sinus pocularis**, or **vesicula prostatica**. This sac is the homologue of the uterus; it is nearly half an inch in length, extends back beneath the third lobe of the prostate, and by its approach to the surface contributes to the prominence of the veru montanum. Its walls, of a yellowish-white colour, are composed of areolar and elastic tissue, mingled towards its fundus with smooth muscular fibre, and it is lined within by a laminated epithelium, the surface layer being formed of flattened cells. The **ejaculatory ducts**, enveloped in longitudinal smooth muscular fibre, take their

course forward by the side of the sinus pocularis, and terminate within its aperture by slit-like openings.

The prostatic portion of the urethra, when distended, is the most dilated part of the canal; but, excepting during the passage of urine, is completely closed by its muscular tissue. The veru montanum contains erectile and muscular tissue, and it is believed that its distention may prevent the semen passing back into the bladder during emission.

The **membranous portion**, the narrowest part of the canal, measures about three lines in diameter, and is about three-quarters of an inch in length along its upper wall, and half an inch on its lower. It extends from the apex of the prostate gland to the bulb of the corpus spongiosum, and passes through the triangular ligament. Its coats are—the mucous membrane, circular muscular coat, and compressor urethræ muscle. The submucous tissue is richly supplied with vessels.

The **spongy portion**, about six inches in length, forms the rest of the extent of the canal, and is lodged in the corpus spongiosum from its commencement at the triangular ligament to the meatus urinarius. It is narrowest in the body, and dilated at each extremity, posteriorly in the bulb, where it is named the **bulbous portion**, and anteriorly in the glans penis, where it forms the **fossa navicularis.** The meatus urinarius is the most constricted part of the canal; so that a catheter, which will enter that opening, may be passed freely through the whole extent of a normal urethra. Opening into the bulbous portion are two small excretory ducts about an inch in length, which may be traced backwards, between the coats of the urethra and the bulb, to the under part of the membranous portion behind the triangular ligament, where they originate in two small, lobulated, and somewhat compressed glands, of about the size of peas, **Cowper's glands.** These glands are enclosed in a thin capsule, their glandular structure being held together by areolar tissue and smooth muscular fibre; smooth muscular fibre is also found as a longitudinal layer, around their excretory ducts. They are situated immediately beneath the membranous portion of the urethra, and are enclosed by the lower segment of the compressor urethræ muscle, so as to be subject to muscular compression. On the whole internal surface of the spongy portion of the urethra, and especially along its lower surface, are numerous small openings of lacunæ, and the apertures of mucous glands situated in the submucous areolar tissue (*glands of Littré*). The openings of the lacunæ are directed forwards, and are liable occasionally to intercept the point of a small catheter in its passage to the bladder. At about an inch and a half from the opening of the meatus, in the upper wall of the urethra, one of the lacunæ is generally found much larger than the rest, and is named the **lacuna magna.**

TESTICLES.

The testicles are two small glandular organs suspended from the abdomen by the spermatic cords, and enclosed in an external tegumentary covering, the scrotum.

The **SCROTUM** is distinguished into two lateral halves or hemispheres by a **raphé**, which is continued anteriorly along the under surface of the penis, and posteriorly along the middle line of the perineum to the anus. Of these two lateral portions the left is somewhat longer than the right, and corresponds with the greater length of the spermatic cord on the left side.

The scrotum is composed of two layers, integument, and a proper covering, the dartos: the integument is thin, devoid of fat, semi-transparent, possesses numerous large sebaceous and sudoriparous glands, is beset with hairs which issue obliquely from the skin, and have prominent roots, and has usually a dark colour from the presence of pigment in the epidermis. The **tunica dartos** is a thin reddish layer composed of unstriped muscular tissue; it forms the proper tunic of the scrotum, and sends inwards a septum, *septum scroti*, which divides the cavity into two sacs for the two testicles. The dartos is continuous around the base of the scrotum with the common superficial fascia of the abdomen and perineum, and in an attenuated form is prolonged upon the penis to the prepuce.

The **SPERMATIC CORD** is the medium of communication between the testicle and the interior of the abdomen; and is composed of arteries, veins, lymphatics, nerves, the excretory duct of the testicle, and investing tunics. It commences at the internal abdominal ring, where the vessels of which it is composed converge, and passes obliquely along the spermatic canal; the cord then escapes at the external abdominal ring, and descends through the scrotum to the posterior border of the testicle. The left cord is somewhat longer than the right, and permits the left testicle to reach a lower level than its fellow.

The **arteries** of the spermatic cord are—the spermatic artery from the aorta; the deferential artery, accompanying the vas deferens, from the superior vesical; and the cremasteric, from the epigastric artery. The **spermatic veins** form a plexus which constitutes the chief bulk of the cord; they are provided with valves at short intervals, and the smaller veins have a peculiar tendril-like arrangement, which has obtained for them the name of *vasa pampiniformia.* The **lymphatics** are of large size, and terminate in the lumbar glands. The **nerves** are the spermatic plexus, which is derived from the aortic and renal plexus, the genital branch of the genito-crural nerve, and the inguinal branch of the ilio-inguinal.

The **vas deferens**, the excretory duct of the testicle, is situated along the posterior border of the cord, where it may be distinguished by the hard and cordy sensation which it communicates to the fingers. It is about a line or a line and a half in thickness;

its parietes are thick and tough, and its canal from one-fourth to one-third the diameter of the entire duct. In **structure** it is composed of three coats—an **external** or **fibrous coat**, which is thin; a **middle** or **muscular coat** which is remarkable for its thickness, and consists of three layers of smooth muscular fibre, namely, external longitudinal, middle circular, and internal longitudinal; and an **internal** or **mucous coat**, the mucous membrane being pale in colour, disposed in longitudinal plaits, and coated with a squamous epithelium, composed of cells containing yellowish pigment granules. In the dilated portion, near its extremity, it presents a reticular appearance, like that of the vesiculæ seminales.

The **coverings of the spermatic cord** are—the spermatic fascia, cremaster muscle, and fascia propria. The spermatic fascia is a prolongation of the intercolumnar fascia, derived from the borders of the external abdominal ring during the descent of the testicle in the fœtus. The cremasteric covering, *erythroid*, is the thin muscular expansion formed by the spreading out of the fibres of the cremaster, which is likewise carried down by the testicle during its descent. The fascia propria is a continuation of the infundibuliform process from the transversalis fascia, which immediately invests the vessels of the cord, and is also obtained during the descent of the testicle.

The **TESTICLE** is a small oblong and rounded gland, about an inch and a half in length, somewhat compressed at the sides and behind, and suspended in the cavity of the scrotum by the spermatic cord.

Its position in the scrotum is oblique, so that the upper extremity is directed upwards and forwards, and a little outwards; the lower, downwards and backwards, and a little inwards; the convex border

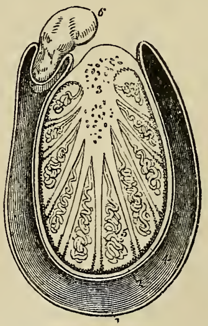

FIG. 415.—Transverse section of the testicle. 1. Cavity of the tunica vaginalis; the most external layer is the parietal layer; and that in contact with the organ, the visceral layer. 2. Tunica albuginea. 3. Mediastinum testis giving off numerous fibrous cords in a radiated direction to the internal surface of the tunica albuginea. The cut extremities of the vessels below the figure belong to the rete testis; and those above to the arteries and veins of the organ. 4. Tunica vasculosa. 5. One of the lobules, consisting of the convolutions of the tubuli seminiferi, and terminating by a single duct, the vas rectum. Corresponding lobules are seen between the other fibrous cords of the mediastinum. 6. Section of the epididymis.

looks forwards and downwards, and the flattened border to which the cord is attached, backwards and upwards. Lying against its outer and posterior border is a flattened body which follows the course of the testicle, and extends from its upper to its lower extremity; this body is named, from its relation to the testis, **epi-**

didymis (ἐπί, upon ; δίδυμος, the testicle) ; it is divided into a central part or **body**, an upper extremity or **globus major**, and a lower extremity, **globus minor** (cauda) epididymis. The globus major is situated against the upper end of the testicle, to which it is closely adherent ; the globus minor is placed at its lower end, is attached to the testicle by areolar tissue, and curves upwards, to become continuous with the vas deferens.

The testicle is invested by three tunics—tunica vaginalis, tunica albuginea, and tunica vasculosa, and is connected to the inner surface of the dartos by a large quantity of extremely loose areolar tissue, in which fat is never deposited, but which is very susceptible of serous infiltration.

The **tunica vaginalis** is a pouch of serous membrane derived from the peritoneum in the descent of the testicle, and afterwards obliterated from the abdomen to within a short distance of the gland. It is a shut sac, investing the organ, *visceral portion*, and then reflected so as to form a bag around its circumference, *parietal portion*. The visceral portion, tunica vaginalis propria, covers the surface of the tunica albuginea, and surrounds the epididymis, connecting it to the testicle by means of a duplicature. The parietal portion, tunica vaginalis communis, is attached by its external surface, through the medium of a quantity of loose areolar tissue, to the inner surface of the dartos. Between the two layers is the smooth surface of the shut sac, moistened by its proper secretion.

At the upper part of the testicle and in front of the globus major of the epididymis one or two small pedunculated bodies are commonly observed ; they are described as the **hydatids of Morgagni**, and are composed of connective tissue and blood-vessels with a covering of tunica vaginalis. The largest of these is regarded as the remains of a fœtal structure called the duct of Müller.

The **tunica albuginea** is a thick areolo-fibrous membrane, of a bluish-white colour, and the proper tunic of the testicle. It is adherent externally to the tunica vaginalis propria, and, from the union of a serous with a fibrous membrane, is regarded as a fibro-serous membrane, like the dura mater and pericardium. After surrounding the testicle, the tunica albuginea is reflected from its posterior border into the interior of the gland, and forms a projecting longitudinal ridge, the **mediastinum testis** (corpus Highmorianum), from which numerous fibrous cords (trabeculæ, septula) are given off, to be inserted into the inner surface of the tunic. The mediastinum serves to contain the vessels and ducts of the testicle in their passage into the substance of the organ, and the fibrous cords are adapted to prevent compression of the gland. If a transverse section of the testicle be made, and the surface of the mediastinum examined, it will be observed that the blood-vessels of the substance of the organ are situated near the posterior border of the mediastinum, while the divided ducts of the rete testis occupy a place nearer the free margin.

The **tunica vasculosa** is the nutrient membrane of the testicle ;

it is situated immediately within the tunica albuginea, and encloses the substance of the gland, sending processes inwards between the lobules; it consists of fine blood-vessels, connected together by an areolar web.

The substance of the testicle consists of numerous conical flattened **lobules**, the bases being directed towards the surface of the organ, and the apices towards the mediastinum. Krause found between four and five hundred of these lobules in a single testicle. Each lobule is invested by a distinct sheath formed of two layers, one being derived from the tunica vasculosa, the other from the tunica albuginea. The lobule is composed of from one to three minute tubuli, **tubuli seminiferi**,* exceedingly convoluted, anastomosing frequently with each other near their extremities, terminating in loops or in free cæcal ends, and of the same diameter, $\frac{1}{170}$ of an inch (Lauth), throughout. The tubuli seminiferi are of a bright yellow colour; they become less convoluted in the apices of the lobules, and terminate by forming between twenty and thirty small straight ducts of about twice the diameter of the tubuli seminiferi, the **vasa recta.** The vasa recta enter the substance of the mediastinum, and terminate in from seven to thirteen ducts, smaller in diameter than the vasa recta. These ducts pursue a waving course from below upwards through the fibrous tissue of the mediastinum; they communicate freely with each other, and constitute the **rete testis.** At the upper extremity of the mediastinum, the ducts of the rete testis terminate in from nine to thirty small ducts, the **vasa efferentia**,† which form by their convolutions a series of conical masses, the *coni vasculosi;* from the bases of these cones tubes of larger size proceed, which constitute, by their complex convolutions, the body of the epididymis. The tubes become gradually larger towards the lower end of the epididymis, and terminate in a single large and convoluted duct, the vas deferens.

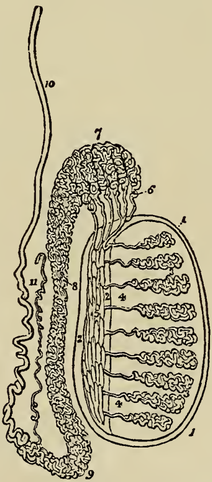

FIG. 416. — Anatomy of the testicle. 1, 1. Tunica albuginea. 2, 2. Mediastinum testis. 3, 3. Lobuli testis. 4, 4. Vasa recta. 5. Rete testis. 6. Vasa efferentia, of which six only are represented in this diagram. 7. Coni vasculosi, constituting the globus major epididymis. 8. Body of the epididymis. 9. Globus minor epididymis. 10. Vas deferens. 11. Vasculum aberrans.

* Lauth estimates the whole number of tubuli seminiferi in each testicle at 840, and their average length at 2 feet 3 inches. According to this calculation, the entire length of the tubuli seminiferi would be 1890 feet.

† Each vas efferens with its cone measures, according to Lauth, about 8 inches. The entire length of the tubes composing the epididymis, according to the same authority, is about 21 feet.

The walls of the seminal tubules are formed of a basement membrane, consisting of several layers of flattened epithelial cells. The tubes are occupied by cells, which are in some places situated at the circumference only, a small lumen or cavity being left in the centre; but in the adult testicle they generally form a confused mass filling up the entire tube.

Between the tubes the blood-vessels, lymphatics, and nerves ramify; they are supported by a peculiar tissue containing a large quantity of nuclear and molecular elements, and in which there are lacunar spaces lined by a flattened epithelium, these spaces being the radicles of the lymphatics.

√ The **epididymis** is formed by the convolutions of the excretory seminal ducts, externally to the testis, and previously to their termination in the vas deferens. The more numerous convolutions and the aggregation of the coni vasculosi at the upper end of the organ constitute the **globus major**; the continuation of the convolutions downwards is the **body**; and the smaller number of convolutions of the single tube at the lower extremity, the **globus minor.** The tubuli are connected together by filamentous areolar tissue, and are enclosed by the tunica vaginalis.

A small convoluted duct, of variable length, is generally connected with the duct of the epididymis, just at the commencement of the vas deferens. This is the **vasculum aberrans** of Haller; it is attached to the epididymis by the areolar tissue in which that body is enveloped. Sometimes it becomes dilated towards its extremity, but more frequently retains the same diameter throughout.

The epithelium lining the rete testis is for the greater part of its extent of the squamous variety, but near its termination the cells are columnar. The lining cells of the vasa efferentia and upper part of the epididymis are columnar or prismatic in form, and are ciliated; in the lower part of the epididymis the cilia disappear.

In front of the spermatic cord, and in contact with the globus major of the epididymis, is a minute irregular structure, which, on microscopic examination, is found to be tubular. It is the remains of the Wolffian body, and is called the **parepididymis** or **organ of Giraldès.**

√ The **vas deferens** may be traced upwards, from the globus minor of the epididymis along the posterior part of the spermatic cord, and along the spermatic canal to the internal abdominal ring. From the ring it is reflected inwards to the side of the fundus of the bladder, and descends along its posterior surface, crossing the direction of the ureter, to the inner border of the vesicula seminalis. In the latter situation it becomes somewhat larger in size and sacculated, and terminates at the base of the prostate gland, by uniting with the duct of the vesicula seminalis, and constituting the ejaculatory duct. The ejaculatory duct, which is thus formed by the junction of the duct of the vesicula seminalis with the vas deferens, passes forwards in the outer wall of the sinus pocularis, and termi-

nates by a slit-like opening close to or just within the aperture of the sinus.

The **TESTICLES IN THE EMBRYO** are situated in the lumbar regions, immediately in front of and somewhat below the kidneys. They have, connected with them inferiorly, a peculiar structure, which assists in their descent, and is called the gubernaculum testis.

The **gubernaculum** is a soft and conical cord, composed of areolar tissue, containing in its areolæ a gelatiniform fluid. In the abdomen it lies in front of the psoas muscle, and passes along the spermatic canal, which it serves to distend for the passage of the testis. It is attached by its superior and larger extremity to the lower end of the testis and epididymis, and by the inferior extremity to the bottom of the scrotum. The gubernaculum is surrounded by a thin layer of muscular fibres, the **cremaster**, which pass upwards upon this body to be attached to the testis. Inferiorly the muscular fibres divide into three processes, which, according to Curling, are thus attached: "The external and broadest is connected to Poupart's ligament in the inguinal canal; the middle forms a lengthened band, which escapes at the external abdominal ring, and descends to the bottom of the scrotum, where it joins the dartos; the internal passes in the direction inwards, and has a firm attachment to the os pubis and sheath of the rectus muscle. Besides these a number of muscular fibres are reflected from the internal oblique on the front of the gubernaculum."

The **descent of the testicle** is gradual and progressive. Between the fifth and sixth month it has reached the lower part of the psoas muscle, and, during the seventh, makes its way through the spermatic canal, and descends into the scrotum.

While situated in the lumbar region, the testicle and gubernaculum are placed behind the peritoneum by which they are invested upon their anterior surface and sides. As they descend the investing peritoneum is carried downwards with the testicle into the scrotum, forming a lengthened pouch, which by its upper extremity opens into the cavity of the peritoneum. The upper part of this pouch, being compressed by the spermatic canal, is gradually obliterated, the obliteration extending downwards along the spermatic cord nearly to the testicle. That portion of the peritoneum which immediately surrounds the testicle is, by the above process, cut off from its continuity with the peritoneum, and is termed the *tunica vaginalis;* and as this membrane must be obviously a shut sac, one portion of it investing the testicle, and the other being reflected so as to form a loose bag around it, its two portions have received the appellations of tunica vaginalis propria, and tunica vaginalis reflexa. In its descent the testicle receives certain structures from the different layers of the abdominal wall; these have been enumerated in connection with the description of inguinal hernia (p. 290), the coverings being exactly the same as those of the oblique form of that affection.

Much difference of opinion obtains as to the means by which the descent of the testicle is effected, Curling and others believing it to result from the traction of the muscle of the gubernaculum, the cremaster, while Cleland positively denies that such traction takes place. If it be not the result of the action of the cremaster, it is difficult to assign the agency by which it is accomplished.

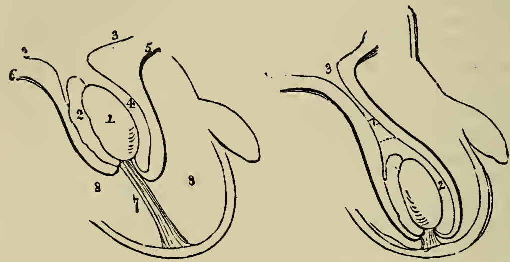

FIG. 417. — Diagram illustrating the descent of the testicle. 1. Testicle. 2. Epididymis. 3, 3. Peritoneum. 4. Pouch formed around the testicle by the peritoneum, the future cavity of the tunica vaginalis. 5. Pubic portion of the cremaster attached to the lower part of the testicle. 6. Portion of the cremaster attached to Poupart's ligament. The mode of eversion of the cremaster is shown by these lines. 7. Gubernaculum attached to the bottom of the scrotum. 8, 8. Cavity of the scrotum.

FIG. 418.—In this figure the testicle has completed its descent. The gubernaculum is shortened to its utmost, and the cremaster completely everted. The pouch of peritoneum above the testicle is compressed so as to form a tubular canal, z. A dotted line marks the point at which the tunica vaginalis will terminate superiorly; and the figure 2 its cavity. 3. Peritoneal cavity.

WOLFFIAN BODIES.

These are peculiar reddish masses which in the early embryo occupy the place of the urino-genital organs. In the human fœtus they reach their full development about the fifth week after conception, after which, as the kidneys and genital organs become evolved, they wither, so that by the end of the third month of utero-gestation no trace of them can be observed.

They are placed on each side of the vertebral column, and extend from the lower part of the abdomen upwards to the heart; they are behind the peritoneum, and are held in place by folds of that membrane, one of which receives the name of the **ligament of the Wolffian body.** In structure each consists of a number of minute tubules, which terminate internally in dilatations closely resembling the Malpighian capsules of the kidney; externally they communicate with a common duct called the **Wolffian duct.** The ducts of the two sides unite after they leave the Wolffian bodies, and form a common tube which opens into the cavity of the allantois; they contain a fluid which resembles urine.

About the time that the Wolffian bodies begin to wither, a line of blastema appears on the surface of each, which at length becomes a tube with a somewhat dilated upper end; these tubes are the

Müllerian ducts. The two ducts pass down at first in front of the Wolffian ducts, but afterwards get behind them; they then unite and terminate in the lower part of the allantois, which is called the **uro-genital sinus.**

The kidneys, ovaries, and testicles are not developed from the Wolffian bodies, but from new blastema which appears behind and internal to them; there seems, however, reason to believe that the vasa aberrantia and coni vasculosi of the epididymis originate in the tubules of the Wolffian body. The Wolffian duct becomes the vas deferens in the male, but in the human female is completely obliterated; in certain animals, as the sow, it is found as the duct of Gaertner. The upper part of the Müllerian duct is represented in the male by the hydatid of Morgagni, and the lower united portion by the sinus pocularis; the intermediate free portion is obliterated. In the female the ducts obtain a greater development, their upper ununited part forming the Fallopian tubes, and their lower united part the uterus.

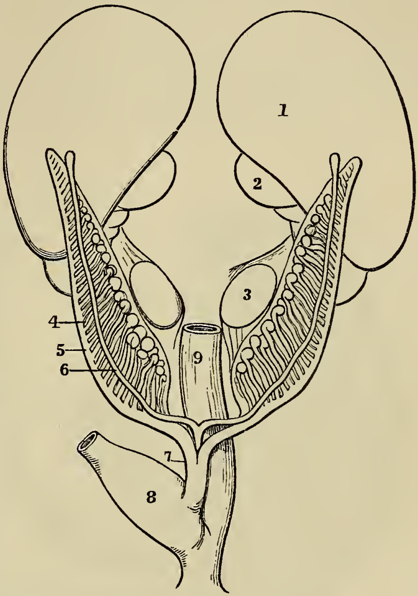

FIG. 419.—Diagram of the Wolffian bodies. 1. Suprarenal capsule. 2. Kidney. 3. Ovary or testicle. 4. Wolffian body. 5. Wolffian duct. 6. Müllerian duct. 7. Genital cord. 8. Uro-genital sinus. 9. Rectum.

FEMALE PELVIS.

The peculiarities in form of the female pelvis have already been examined with the anatomy of the bones (p. 155). Its lining boundaries are the same as those of the male. The contents are the bladder, vagina, uterus with its appendages, and rectum. Some portion of the small intestine also occupies the upper part of its cavity.

The **bladder** is in relation with the pubes in front, with the uterus behind, from which it is usually separated by a convolution of small intestine, and with the neck of the uterus and vagina be-

neath. The form of the female bladder corresponds with that of the pelvis, being broad from side to side, and often bulging more on one side than on the other. This is particularly evident after parturition. The *coats* of the bladder are the same as those of the male.

The **urethra**, about an inch and a half in length, is lodged in the upper and anterior wall of the vagina, in its course downwards and forwards, beneath the arch of the pubes, to the meatus urinarius. It is composed of three coats, mucous, submucous, and muscular;

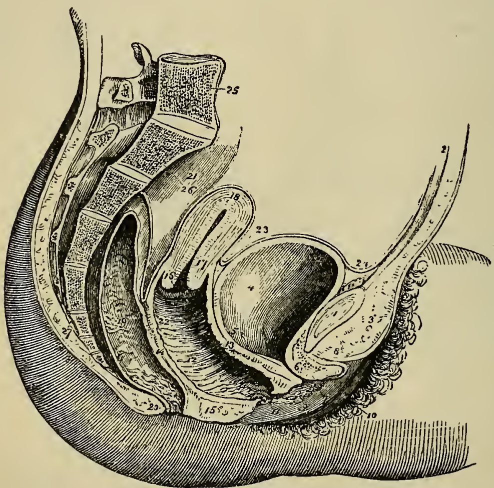

Fig. 420.—Side view of the viscera of the female pelvis. 1. Symphysis pubis; to the upper part of which the tendon of the rectus muscle is attached. 2. Abdominal parietes. 3. Collection of fat, forming the prominence of the mons Veneris. 4. Urinary bladder. 5. Entrance of left ureter. 6. Canal of the urethra, converted into a mere fissure by the contraction of its walls. 7. Meatus urinarius. 8. Clitoris, with its prepuce divided through the middle. 9. Left nympha. 10. Left labium majus. 11. Meatus of the vagina, narrowed by the contraction of its sphincter. 12, 22. Canal of the vagina, on which the transverse rugæ are apparent. 13. Thick wall of separation between the base of the bladder and the vagina. 14. Wall of separation between vagina and rectum. 15. Perineum. 16. Os uteri. 17. Cervix. 18. Fundus uteri. The cavity of the uterus is seen along the centre of the organ. 19. Rectum, showing the disposition of its mucous membrane. 20. Anus. 21. Upper part of rectum, invested by peritoneum. 23. Utero-vesical fold of peritoneum. The recto-uterine fold is seen between the rectum and posterior wall of the vagina. 24. Reflection of peritoneum, from the apex of the bladder upon the urachus to the internal surface of the abdominal parietes. 25. Last lumbar vertebra. 26. Sacrum. 27. Coccyx.

the **mucous coat** is vascular, and disposed in longitudinal folds, and is continuous internally with the mucous membrane of the bladder and externally with that of the vulva. It is provided with a squamous epithelium, having a deep stratum of elongated cells, like the mucous membrane of the bladder, and near its extremity has, opening on its surface, the ducts of numerous racemose mucous glands, the glands of Littré. The **submucous coat** is loose, and provided with a considerable plexus of veins, and in its areolar tissue are situated the racemose mucous glands, which open into the

urethra near its termination. The **muscular coat** consists of two layers, which are continuous with the muscular structure of the bladder, the internal layer being longitudinal, and mingled with areolar and elastic tissue; the external circular, and continuous with the middle layer of the muscular coat. The female urethra is remarkable for its distensibility, which is only restricted at the meatus by a ring of dense areolar tissue; hence, in distending the urethra for surgical purposes, it is often necessary to divide the margin of the meatus with the knife.

VAGINA.

The vagina is a membranous canal, leading from the vulva to the uterus, and corresponding in direction with the axis of the outlet of the pelvis. It is constricted at its commencement, but near the uterus becomes dilated, and is closed by the contact of the anterior with the posterior wall. Its length is variable; but it is always longer on the posterior than on the anterior wall, the former being usually about five or six inches in length, the latter about four. It is attached to the cervix of the uterus, which latter projects into the upper extremity of the canal. Its upper fourth is covered posteriorly by the peritoneum, while anteriorly the peritoneum is reflected from the cervix uteri without reaching so low as the vagina; it is firmly connected to the bladder in front, and loosely to the rectum behind; while at the sides it receives the attachment of the posterior layer of the broad ligaments above, and that of the pelvic fascia and levatores ani below. Its close connection with the bladder occasions the prolapsus of that organ in cases of prolapsus uteri, while its looser connection with the rectum preserves the latter from a similar accident.

Structure.—The vagina, about one line in thickness, is composed of three coats: external, fibrous; middle, muscular; and internal, mucous. The **external** or **fibrous coat** is thin and white, and consists of condensed areolar tissue, with an admixture of elastic fibres. It is firm around the upper part of the tube, and lax inferiorly, and contains in its tissue, especially below, an abundant venous plexus. By its inner surface it is blended with the muscular coat without any distinct separation. The **middle** or **muscular coat** is composed of smooth muscular fibre, arranged in longitudinal and circular bundles, and intermingled with areolar tissue and a considerable plexus of veins. The **internal** or **mucous coat** is of a pale red colour, and disposed in numerous plaits or folds, **columnæ rugarum**; which diverge transversely from a middle line, or raphé, situated on the anterior and posterior wall of the vagina; the rugæ are most strongly developed on the anterior wall, and the median raphé are termed **columns of the vagina.** In intimate structure the mucous membrane consists of areolar and elastic tissue, to which its firmness and elasticity are due, and presents numerous conical

papillæ embedded in a squamous epithelium. The **epithelium** is thick and laminated, resembling that of the œsophagus, its upper scales measuring about $\frac{1}{1000}$ of an inch in diameter; it is continuous externally with the epithelium of the vulva, and terminates internally at about the middle of the cervix uteri. Opening on to the surface of the mucous membrane are numerous mucous follicles and glands, these being especially plentiful in the upper smooth portion of the vagina and around the cervix uteri.

UTERUS.

The uterus is a flattened organ of a pyriform shape, having the base directed upwards and forwards, and the apex downwards and backwards, in the line of the axis of the inlet of the pelvis, and forming a considerable angle with the course of the vagina. It is convex on its posterior surface, and somewhat flattened in front; in the unimpregnated state it is about three inches in length, two in breadth across it broadest part, and one in thickness; and is divisible into fundus, body, cervix, and os uteri. At the period of puberty the uterus weighs about one ounce and a half; after parturition from two to three ounces; and at the ninth month of utero-gestation from two to four pounds.

The **fundus** and **body** are enclosed in a duplicature of peritoneum, which is connected with the sides of the pelvis, and forms a transverse septum between the bladder and rectum. The folds formed by this duplicature of peritoneum at each side of the organ are the **broad ligaments.** The **cervix** is the lowest portion of the uterus; it is distinguished from the body by a well-marked constriction; around its circumference is attached the upper end of the vagina, and at its extremity is an opening which is nearly round in the virgin, and transverse after parturition, the **os uteri** (os tincæ), bounded before and behind by two labia; the posterior labium being somewhat longer than the anterior, and somewhat less thick. The opening of the os uteri is of considerable size, and is named the **os uteri externum**; the canal then becomes narrowed, and at the upper end of the cervix is constricted into a smaller opening, the **os internum.** Beyond this point the canal of the cervix expands into the shallow triangular cavity of the uterus, the inferior angle corresponding with the os internum, and the two superior angles, which are funnel-shaped and represent the original bicornute condition of the organ, with the commencement of the Fallopian tubes.

Structure.—The uterus is composed of three tunics: of an *external* or *serous coat*, derived from the peritoneum, which constitutes the duplicatures at each side of the organ called the broad ligaments; of a *middle* or *muscular coat*, which gives thickness and bulk to the uterus; and of an *internal* or *mucous membrane*, which lines its interior, and is continuous on the one hand with the

mucous lining of the Fallopian tubes, and on the other with that of the vagina. In the unimpregnated state the **muscular coat** is exceedingly dense in texture, offers resistance to section with the scalpel, and appears to be composed of whitish fibres inextricably interlaced and mingled with blood-vessels. In the impregnated uterus the fibres are of large size, distinct, and separable into three layers: *external*, which are longitudinal and transverse, the former constituting a thin plane on the anterior and posterior surface and fundus of the organ, the latter being prolonged outwards on the Fallopian tubes, and into the round and ovarian ligaments; *middle*, a thick layer consisting of flat bundles of transverse, longitudinal, and oblique fibres, complexly interlaced, and traversed by a plexus of large veins, which give this portion of the substance of the uterus

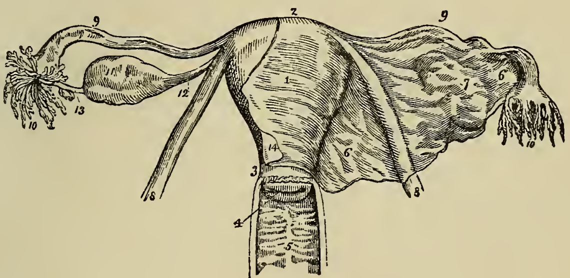

FIG. 421.—Uterus with its appendages viewed from the front. 1. Body of the uterus. 2. Fundus. 3. Cervix. 4. Os uteri. 5. Vagina; the figure is placed on the posterior raphé or columna, from which the transverse rugæ are seen passing off at each side. 6, 6. Broad ligament of the uterus. 7. Convexity of the broad ligament formed by the ovary. 8, 8. Round ligaments of the uterus. 9, 9. Fallopian tubes. 10, 10. Fimbriated extremities of the Fallopian tubes; on the left side the mouth of the tube is turned forwards in order to show its ostium abdominale. 11. Ovary. 12. Utero-ovarian ligament. 13. Fallopio-ovarian ligament, on which some small fimbriæ are continued for a short distance. 14. Peritoneum of anterior surface of uterus. This membrane is removed at the left side, but on the right is continuous with the anterior layer of the broad ligament.

a spongy appearance; and an *internal* layer of longitudinal, transverse, and oblique fibres. The longitudinal fibres of the internal or deep layer are thin and slender, the transverse stronger and continued as an annular stratum upon the Fallopian tubes, while around the os uteri they form a circular ring, the *sphincter uteri.* The formative elements of the muscular coat are short, fusiform fibre cells, about $\frac{1}{500}$ of an inch long, with long oval nuclei, intermingled with a considerable quantity of immature nucleated areolar tissue.

The **mucous membrane**, of a whitish or pale red colour, is closely connected, or more correctly, is blended with the muscular coat; it is composed of immature nucleated areolar tissue without elastic fibres, is smooth on the surface, and coated by a *ciliated epithelium*,

the direction of the vibrations of the cilia being from without inwards. In the cervix uteri the mucous membrane is somewhat thicker than in the fundus, and on the anterior and posterior surface of its canal is disposed in folds, **plicæ palmatæ**, which have received the name of **arbor vitæ uterina.** In the lower part of the cervix, moreover, are found filiform papillæ, invested by a ciliated epithelium.

The **mucous glands** of the uterus, or *uterine glands*, are minute follicles corresponding in length with the thickness of the mucous membrane, very numerous, sometimes simple, sometimes bifid, and sometimes spirally twisted. Their structure resembles other mucous glands, namely, a basement membrane, an epithelium of prismatic cells, with their broad bases and nuclei towards the basement membrane, and their narrow ends towards the lumen of the gland. Many of the cells near the mouth of the follicle are surmounted by cilia, the deeper ones being devoid of them. The glands become much enlarged during pregnancy. In the cervix uteri, between the plicæ palmatæ, are found other *mucous* follicles which secrete the peculiar, transparent, vitreous or crystalline mucus of that region. It is these follicles in an imperforate state which constitute the small transparent vesicles termed **ovula Nabothi**, seen in the canal of the cervix around the os uteri, and sometimes in its cavity.

Vessels and Nerves.—The *arteries* of the uterus are—the uterine from the internal iliac, and the ovarian from the aorta; they ramify through the muscular and mucous coat, forming a plexus of larger vessels in the deep portion of the latter, and of smaller vessels in its superficial portion; from the smaller vessels are given off the capillaries, which constitute a fine plexus around the glands and a coarse plexus at the surface, the blood from the latter passing into the veins. The *veins* take the course of the arteries, and terminate in the venous plexus situated on each side of the body of the uterus. In the impregnated womb, the veins are so much dilated as to deserve the name of *sinuses;* they are thin in structure, and devoid of valves, and their great number in the muscular coat gives a spongy appearance to the walls of the pregnant uterus. The *lymphatics* are numerous, the deep commencing in the mucous membrane, the superficial taking their course in the subserous tissue; they follow the direction of the blood-vessels, and terminate in the pelvic and lumbar glands.

The **nerves** of the uterus are derived from the hypogastric and spermatic plexuses, and from the sacral plexus. These form a very elaborate plexus, in the midst of which numerous ganglia are found. Of these latter the chief are—one, called the *hypogastric ganglion*, which is situated at the side of the cervix just behind the ureter; another, *spermatic ganglion*, which supplies the fundus uteri; and a number of smaller ones, called posterior and anterior *subperitoneal*, *vesical*, and *vaginal ganglia.*

The nerves of the uterus all increase in size during pregnancy, and again decrease after parturition.

APPENDAGES OF THE UTERUS.

The appendages of the uterus are enclosed by the lateral duplicatures of peritoneum called the broad ligaments. They are the *Fallopian tubes* and *ovaries.*

The **FALLOPIAN TUBES** or **oviducts**, the uterine trumpets of the French writers, are situated in the upper border of the broad ligaments, and are connected with the superior angles of the uterus. They are somewhat trumpet-shaped, being smaller at the uterine than at the free extremity. The narrow inner extremity has been named by Henle the *isthmus*, and the wider outer half the *ampulla.* Each tube is about four inches in length, and more or less flexuous in its course. The canal of the Fallopian tube is exceedingly minute; its inner extremity opens by means of the **ostium uterinum** into the upper angle of the cavity of the uterus, and the opposite end into the cavity of the peritoneum. The free or expanded extremity of the Fallopian tube presents a double and sometimes a triple series of small processes or fringes which surround the margin of the trumpet or funnel-shaped opening, the **ostium abdominale.** This fringe-like appendage to the end of the tube has gained for it the appellation of the **fimbriated extremity**; and the remarkable manner in which this circular fringe applies itself to the surface of the ovary during sexual excitement, the additional title of *morsus diaboli.* A short ligamentous cord proceeds from the fimbriated extremity to be attached to the distal end of the ovary, and serves to guide the tube in its seizure of that organ.

Structure.—The Fallopian tube is composed of three tunics—an **external** and **serous** investment derived from the peritoneum; a **middle** or **muscular coat**, consisting of circular (internal) and longitudinal (external) fibres, continuous with those of the uterus; and an **internal** or lining **mucous** membrane, which is continuous on the one hand with the mucous membrane of the uterus, and at the opposite extremity with the peritoneum. The fibres of smooth muscle are mingled, as in the uterus, with immature nucleated areolar tissue. The mucous membrane is thin, pale, and soft, without villi or glands, and disposed in longitudinal plaits. It is invested by an **epithelium** consisting of a single layer of conical or filiform ciliated cells, the direction of the vibrations of the cilia being towards the cavity of the uterus. The inner surface of the fimbria is covered with ciliated epithelium, and this is continued for a short distance on to the outer surface, but soon passes into the squamous form, similar in character to the cells covering the peritoneum.

If the broad ligament of the uterus be held up to the light, a few scattered tubules will be seen between the ovary and Fallopian tube. These constitute the **par ovarium** or **organ of Rosenmüller.** They are lined with epithelium, and are closed at their ovarian extremity, but communicate at the other end with an imperfect

duct, which in the sow and some other animals forms the **duct of Gaertner.** The par ovarium is developed along with the Wolffian body, and seems to be the representative in the female of the coni vasculosi of the testicle of the male.

✓ The **OVARIES** (*testes muliebres*) are two oblong, flattened, and oval bodies, of a whitish colour and uneven surface, situated in the posterior layer of peritoneum of the broad ligaments. They are connected to the upper angles of the uterus at each side by means of a rounded cord, consisting of fibrous tissue, and a few muscular fibres derived from the uterus, the **ligament of the ovary.** By the opposite extremity they are connected by another and a shorter ligament to the fimbriated aperture of the Fallopian tube.

Structure.—The ovary is composed of a spongy fibrous stroma of a greyish-red colour, containing a number of small cells traversed by blood-vessels, and is covered by a serous membrane which in the early history of the organ was evidently a continuation of the peritoneum. The cells of this outer membrane differ from those of the peritoneum in being columnar or prismatic, and in their giving to the surface a dull appearance instead of the smooth glistening character usually distinguishing serous membranes; the cells have received the name of **germ epithelium** because they originate the ova. Beneath this membrane is a layer of condensed stroma, having a white appearance, and called from its supposed resemblance to one of the coats of the testicle the *tunica albuginea.* The deep part of the stroma is formed of fibrous tissue containing a large number of nuclei and some elastic tissue; the fibres radiate from the attached border or *hilus* towards the circumference in small bundles, between which and near the surface of the ovary are seen a number of vesicles termed *ovisacs* or *Graafian vesicles.*

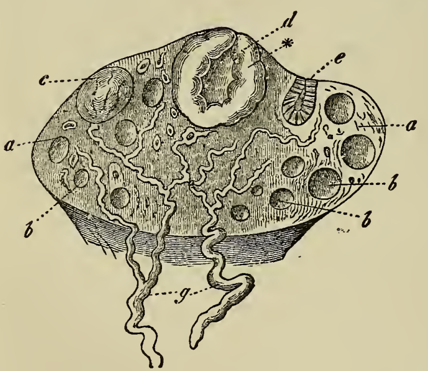

Fig. 422.—The ovary. *a, a.* Stroma. *b, b, b.* Small Graafian vesicles. *c.* A mature vesicle. *d.* A fresh corpus luteum, with thick lining *. *e.* An old corpus luteum. *g.* Veins.

The **ovisac** or **Graafian vesicle** is a vesicle consisting of an external membrane and fluid contents. The membrane is composed of an outer coat, the **tunica fibrosa,** and an internal lining or **epithelium.** The tunica fibrosa is highly vascular, is connected to the stroma of the ovary by means of a loose areolar tissue, and is composed of condensed immature areolar tissue. Externally, it

is whitish and firm; internally, reddish and soft. The epithelium consists of round or polygonal cells with large nuclei, and a greater or less number of fatty granules; the cells quickly lose their definition after death, and then the epithelium assumes the appearance which has gained for it the name of **membrana granulosa,** namely, a granular layer with numerous nuclei. The membrana granulosa forms a uniform lining to the ovisac, excepting on the side nearest the surface of the ovary, where the cells are accumulated into a small eminence, termed **discus proligerus** or **germinal eminence.** This germinal eminence contains a minute globular nucleated vesicle, the **ovum.** The fluid contents of the ovisac, *liquor folliculi,* are a clear yellowish fluid, and a few free albuminous cells detached from the membrana granulosa. The Graafian vesicles are very small in the outer part of the ovary, but are there so numerous as to give a granular character distinct from that of the rest of the organ; hence it is defined as the *cortical portion.* In the deeper portions they are less numerous but larger and more mature, and as they increase in size they displace the cells of the cortical portion in order to reach the surface of the organ.

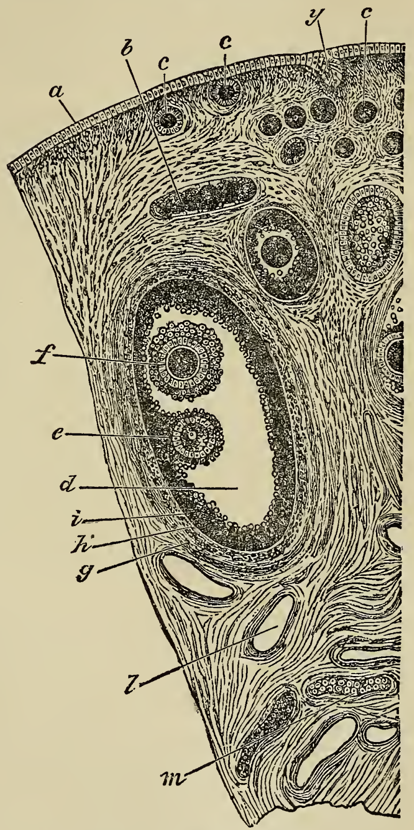

Fig. 423.—Section of ovary. *a.* Germ epithelium. *b.* Ovarian tube, or string of ovigerms. *c, c, c.* Early vesicles. *d.* A more mature vesicle. *e.* Ovum and discus proligerus. *f.* A second ovum in the same vesicle. *g.* Tunica fibrosa of vesicle. *h.* Inner coat of the vesicle. *i.* Epithelial lining (tunica granulosa). *l.* Blood-vessel, cut across. *m.* Section of tubes of par ovarium. *y.* Involuted portion of germ epithelium of surface.

Ovum.—The ovum, measuring in its mature state about $\frac{1}{100}$ of an inch in diameter, is a globular vesicle consisting of a cell mem-

brane, the **vitelline membrane**, a **yelk** or **vitellus**, and a vesicular nucleated nucleus, the vesicular nucleus being the **germinal vesicle**, and the nucleolus the **germinal spot.** The cell membrane is clear and transparent, and has received the name of **zona pellucida**, and the **yelk**, yellowish and viscid, consists of numerous minute granules intermingled with fat granules; the fluid of the germinal vesicle is clear and colourless.

As the ovisac attains maturity, it approaches nearer and nearer the capsule of the ovary, and pressing against the capsule renders it so thin that moderate pressure, such as that made by the fibriated extremity of the Fallopian tube, causes the protrusion and rupture both of the ovisac and the capsule of the ovary. By this rupture the ovum is expelled, carrying with it the germinal eminence and part of the membrana granulosa, which in its new relation is termed the *germinal disc*, **discus proligerus.** The ovisac, now emptied of its contents, is quickly filled with a sanguineous fluid, resulting from the tearing of its vessels, the internal portion of the tunica fibrosa becomes thickened and plicated, and converted into a yellow vascular tissue, while the external layer of the tunic retains its character of a white fibrous membrane. This is the **corpus luteum,** a yellowish mass with fast-diminishing cavity, plicated structure, vascular, and enclosed in a thin fibrous layer. It retains these characters up to the second or third month of pregnancy, and then slowly diminishes in size, being gradually lost some months after parturition is complete, or reduced to a small whitish or dark coloured mass. The corpora lutea, which are independent of pregnancy, **false corpora lutea**, disappear in the course of one or two months, and leave behind them a scarcely perceptible trace of their existence.

Formation of Ova.—The ova are formed from the germ epithelium on the surface of the ovary, the cells becoming enlarged and penetrating into the substance of the ovum as shown at *y*, fig. 423. After passing downwards for a short distance they lose their surface connection, and become enveloped by layers of condensed stroma constituting the walls of the Graafian vesicles; the germ cell thus comes to form the ovum, its nucleus the germinal vesicle, and a nucleolus which soon appears in the centre of the nucleus the germinal spot. The cells of the membrana granulosa are (as shown by Dr. James Foulis) the product of the nuclei of the fibro-nuclear tissue forming the stroma.

Vessels and Nerves.—The *arteries* of the ovaries are branches of the uterine and ovarian. The arteries enter the ovary along its inferior border by numerous minute trunks, which pass in a serpentine course through its stroma, to be distributed chiefly to the walls of the ovisacs, forming an exterior coarse and interior fine capillary plexus. The *veins* constitute an ovarian plexus, which terminates in the uterine plexus. The *lymphatics*, few in number, terminate in the pelvic and lumbar glands. The *nerves* are derived from the spermatic plexus, and take the course of the arteries.

The **ROUND LIGAMENTS** are two musculo-fibrous cords between four and five inches long, situated within the layers of the broad ligaments, and extending from the upper angles of the uterus and along the spermatic canals to the labia majora, in which they are lost. They are composed of smooth muscular fibre and areolar tissue, but towards the internal abdominal rings, have also numerous fasciculi of striated muscular fibres. The round ligaments are accompanied by a small artery, by several filaments of the spermatic plexus of nerves, by a plexus of veins, and by a process of the peritoneum which represents the serous membrane investing the spermatic cord in the male. In the young subject, this process extends for a short distance along the spermatic canal, and is denominated the **canal of Nuck**: it is sometimes pervious in the adult. The plexus of veins occasionally becomes varicose, and forms a small tumour at the external abdominal ring, which has been mistaken for inguinal hernia. The round ligaments serve to retain the uterus in position in the pelvis, and, during utero-gestation, to draw the anterior surface of the organ against the abdominal parietes.

EXTERNAL ORGANS OF GENERATION.

The female organs of generation are divisible into internal and external; the internal are contained within the pelvis, and have been already described; they are—the vagina, uterus, ovaries, and Fallópian tubes. The external organs are the mons Veneris, labia majora, labia minora, clitoris, meatus urinarius, and opening of the vagina.

The **mons Veneris** is the eminence of integument, situated on the front of the pubes. Its areolar tissue is loaded with adipose substance, and the surface covered with hairs.

The **labia majora** are two large longitudinal folds of integument containing areolar tissue, fat, and a tissue resembling the dartos. They enclose an elliptical fissure, the common urino-sexual opening or **vulva**. The vulva receives the inferior opening of the urethra and vagina, and is bounded anteriorly by the *anterior commissure*, and posteriorly by the *posterior commissure*. Stretching across the posterior commissure is a small transverse fold, the *frænulum labiorum* or **fourchette**, which is ruptured during parturition; and immediately within this fold a small cavity, the **fossa navicularis**. The length of the perineum is measured from the posterior commissure to the margin of the anus, and is usually not more than an inch. The external surface of the labia is covered with hairs; the inner surface is smooth, and lined by mucous membrane, which contains a number of large sebaceous glands, and is covered by a thin cuticular epithelium. The use of the labia majora is to favour the expansion of the vulva during parturition; for, in the passage of the head of the fœtus, the labia are unfolded and completely effaced.

The **labia minora**, or **nymphæ**, are two smaller folds, situated

within the labia majora. Superiorly they are divided into two processes, which surround the glans clitoridis, the superior fold forming the **præputium clitoridis**, the inferior its **frænulum.** Inferiorly, they diminish gradually in size, and are lost on the sides of the opening of the vagina. The nymphæ consist of mucous membrane, covered by a thin cuticular epithelium. They are provided with a number of sebaceous glands, and contain, in their interior, a plexus of blood-vessels.

The **clitoris** is a small elongated organ situated in front of the pubes, and supported by a suspensory ligament. It is formed by a small body, analogous to the corpus cavernosum penis, and, like it, arises from the ramus of the os pubis and ischium at each side by two **crura.** At the extremity of the clitoris is a small accumulation of erectile tissue which is highly sensitive, and is termed the **glans.** The corpus cavernosum clitoridis, like that of the penis, is composed of erectile tissue enclosed in a dense layer of fibrous membrane and is susceptible of erection. Like the penis, also, it is provided with two small muscles, the **erectores clitoridis.**

At about an inch behind the clitoris, is the **entrance of the vagina**, an elliptical opening, marked by a prominent margin. The entrance to the vagina is closed in the virgin by a duplicature of mucous membrane of a semilunar form, which is stretched across the opening; this is the **hymen.** Sometimes the membrane forms a complete septum, and gives rise to inconvenience by preventing the escape of the menstrual effusion. It is then called an *imperforate hymen.* The *hymen* must not be considered a necessary accompaniment of virginity, for its existence is uncertain. When present, it assumes a variety of appearances; it may be a membranous fringe, with round opening in the centre; or a semilunar fold, leaving an opening in front; or a transverse septum, having an opening both in front and behind; or a vertical band with an opening at each side.

The rupture of the hymen, or its rudimentary existence, gives rise to the appearance of a fringe of papillæ around the opening of the vagina; these are called **carunculæ myrtiformes.**

The triangular smooth surface between the clitoris and the entrance of the vagina, which is bounded at each side by the upper portions of the nymphæ, is the **vestibule.**

At the posterior part of the vestibule and near the margin of the vagina is the opening of the urethra, the **meatus urinarius**; and around the meatus an elevation of the mucous membrane formed by the aggregation of numerous mucous glands. This prominence serves as a guide to finding the meatus in the operation of introducing the female catheter. Beneath the vestibule at each side, and extending from the clitoris to the side of the vagina, are two oblong or pyriform bodies, consisting of erectile tissue enclosed in a thin layer of fibrous membrane. These bodies are narrow above, broad and rounded below, and are termed by Kobelt, who considers them analogous to the bulb of the male

urethra, the **bulbi vestibuli.** Behind these bodies and lying against the outer wall of the vagina are two small glands analogous to Cowper's glands in the male subject; they are the **glands of Bartholin** or **Duvernay.** Each gland opens by means of a long excretory duct on the inner side of the corresponding nympha. In front of the masses of erectile tissue forming the bulb of the vestibule is a smaller plexus of vessels continuous with those of that body behind and with the erectile tissue of the glans clitoridis in front; it has been named by Kobelt the *pars intermedia*, and is supposed to correspond with the corpus spongiosum penis lying in front of the bulb of the urethra.

The **mucous membrane** of the external organs, about a quarter of a line in thickness, is composed of areolar and elastic tissue, without fat, and rich in capillary vessels. It is furnished with numerous papillæ, which are large on the labia minora, smaller on the clitoris, and is invested by a squamous epithelium. On the internal surface of the labia majora, on the labia minora, and occasionally around the meatus urinarius and entrance of the vagina, there exist **sebaceous glands**; while on the vestibule, around the meatus urinarius and around the entrance of the vagina, there is an abundance of **racemose mucous glands**, opening on the surface of the membrane by shorter and longer ducts.

Vessels and Nerves.—The external organs of generation are abundantly supplied with *arteries*, chiefly by the internal pudic; they terminate in a deep and superficial capillary plexus, as in other mucous membranes. Valentin has described helicine arteries in the clitoris. The *veins* returning the blood from the capillaries form a rich plexus, which is especially abundant in the bulbi vestibuli of Kobelt. The *lymphatics* are numerous, and communicate partly with the inguinal and partly with the pelvic glands. The *nerves* are derived partly from the hypogastric plexus and partly from the sacral plexus.

MAMMARY GLANDS.

The **mammæ** are situated in the pectoral region, and are separated from the pectoralis major muscle by a thin layer of superficial fascia. Their base is somewhat elliptical, the long diameter corresponding with the direction of the fibres of the pectoralis major muscle; and the left mamma is generally a little larger than the right. They exist in the male, but in a rudimentary state, unless excited into growth by some peculiar or morbid action.

Near the centre of the convexity of each mamma is a small prominence of the integument, called the **nipple** (mammilla), which is surrounded by an **areola** having a coloured tint. In females of fair complexion before impregnation, the colour of the areola is a delicate pink; after impregnation, it enlarges and assumes a brownish hue, which deepens in colour as pregnancy advances; and after the birth of a child, the brownish tint continues through life.

The areola is furnished with a number of **sebaceous glands**, which secrete a peculiar fatty substance for the protection of the delicate integument around the nipple. During suckling these glands increase in size, and have the appearance of small pimples, projecting from the skin. At this period they serve by their secretion to defend the nipple and areola from the excoriating action of the mouth of the infant.

In *structure*, the mamma is a compound racemose or conglomerate gland, consisting of **lobes, lobules,** and **gland-vesicles.** The lobes, from 15 to 25 in number, have each a separate system of lobules and gland-vesicles, and a distinct excretory duct; hence, the mamma may be regarded as being composed of a number of separate glands, their excretory ducts converging to the nipple, and terminating at its extremity by distinct apertures. The lobes are irregular in size and form, flattened, and bounded by rounded angles; they are made up of smaller lobes or lobules, and the lobules of other lobules still more diminutive, the smallest lobules consisting of round or pyriform gland-vesicles.

The **gland-vesicles,** about $\frac{1}{200}$ of an inch in diameter, are composed of a basement membrane, lined with an *epithelium*, of spheroidal nucleated cells. The gland-vesicles communicate with an excretory duct, and the excretory ducts of all the lobules unite to form a common excretory duct or canal for each lobe, **galactophorus duct.** The duct, taking its course beneath the areola, dilates into an elongated sac or **ampulla**, and reaching the base of the mammilla, contracts in size and bends outwards into that process to terminate at its extremity by a small aperture. There are from 15 to 25 ducts in the nipple, a number corresponding with the number of lobes composing the gland.

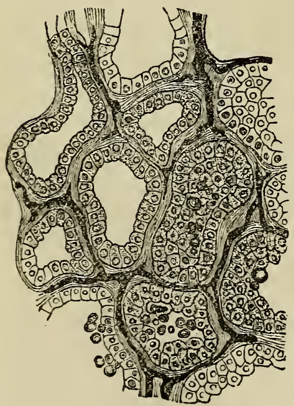

FIG. 424.—Gland-vesicles of the mammary gland during lactation, showing the lining cells and capillary vessels.

The gland-vesicles are held together by a dense white areolar tissue, which unites the lobules into lobes, and connects the different lobes with each other, forming a covering for the whole, and being itself surrounded with adipose tissue. The galactophorus ducts are composed of areolar tissue, with longitudinal and circular elastic fibres, and, according to Henle, there is an indication of longitudinal smooth muscular fibre; they are lined by columnar epithelium, passing into the squamous form near the openings on the nipple.

The **mammilla** or **nipple** is covered by a thin epidermis, present-

ing more or less pigment in its rete mucosum; it possesses at the extremity a number of papillæ, between which are the lactiferous openings, and it is composed internally of the ducts, united together and surrounded by areolar and smooth muscular tissue, the latter giving the nipple the faculty of erection and retraction. The integument of the **areola**, besides possessing a coloured epidermis with numerous large sudoriparous and sebaceous glands, the latter associated with fine hairs, is also provided with a layer of smooth muscular fibre, which gives it a power of contraction.

The **secretion of milk** is effected by the formation of oil-globules in the epithelial cells of the gland-vesicles; the epithelial cells being perfected, are pushed outwards and displaced by a new layer of similar cells which form beneath them; they are thus carried forward into the lacteal ducts, where the cell bursts and gives exit to its oil-globules, now become *milk-globules;* and the cell-membrane and nucleus are lost. These milk-globules suspended in a fluid, the *milk-plasma*, constitute *the milk.* Previously to conception, the mammæ only secrete a yellowish viscid mucus, and at the commencement of lactation the milk is imperfect and termed *colostrum*, having entering into its composition a number of cells filled with yellow fat globules, named *colostrum corpuscles.*

The **mammary gland of the male** is rudimentary; it varies in size from a quarter of an inch to two inches in breadth, by one to three lines in thickness. It is firm in texture, presents no division into lobes, and its ducts are small without dilatations, and terminate in gland-vesicles larger than those of the female.

The **development** of the mammary gland commences at the fourth or fifth month of embryonic life, at first by a papilla of the rete mucosum, which subsequently gives off primary and secondary branches; the papilla and its branches are for a time solid, but as development advances they become hollow and invested externally by a fibrous membrane. At birth the gland measures between two and four lines in breadth, and presents from twelve to fifteen lobular divisions, and then goes on gradually, but very slowly, increasing in bulk. True gland-vesicles do not make their appearance until the period of menstruation, and are not fully developed throughout the entire gland until the first pregnancy. After the period of child-bearing, the gland generally degenerates, the gland-vesicles disappear, and in old age the organ passes into a state of atrophy, the ducts, with their epithelium in a state of fatty degeneration, alone remaining, surrounded by a cushion of fat which takes the place of the glandular tissue.

Vessels and Nerves.—The mammæ are supplied with *arteries* from the thoracic branches of the axillary, the intercostals, and internal mammary; having entered the substance of the gland they divide into capillaries, which constitute a close network around the gland-vesicles. The *veins* form an incomplete circle around the base of the nipple, *circulus venosus Halleri*, from which larger veins conduct the blood to the circumference of the gland, and by these

communications form a plexus on its surface. They terminate in the axillary vein, internal mammary, intercostals, and jugular veins.

The *lymphatics* are abundant in the integument covering the mammæ, but have not yet been observed in the structure of the gland; they take the course of the veins, inwards, to the anterior mediastinal glands; and outwards along the border of the pectoralis major to the axillary glands.

The *nerves* of the mammary gland are derived from the anterior cutaneous branches of the second, third, and fourth intercostal nerve, and from the lateral cutaneous branches of the same nerves.

GLOSSARY OF ANATOMICAL TERMS.

Abdomen (Lat. *abdo*, I conceal). The inferior cavity of the trunk, containing the stomach, intestines, liver, &c.

Abductor (Lat. *abduco*, I draw from). A muscle which carries the limb *away from* the middle line of the body, or the digits from the middle line of the hand or foot.

Accessorius (Lat. *accedere*, to be added to). Muscles or nerves which assist others in their action are thus named.

Acervulus (dim. of Lat. *acervus*, a heap). Applied to the mass of gritty particles contained in the pineal gland.

Acetabulum (Lat. *acetabulum*, a vessel for holding vinegar). The cup-shaped cavity of the innominate bone which receives the head of the femur.

Acini (Lat. *acinus*, the stone of grapes or mulberries). The small vesicles which form conglomerate glands.

Acromion (Gk. ἄκρον, the extremity, and ὤμος, the shoulder). The part of the scapula forming the tip of the shoulder.

Adipose (Lat. *adeps*, fat). Fatty.

Adductor (Lat. *adduco*, I draw to). A muscle which carries the limb *towards* the middle line of the body, or the digits towards the middle line of the hand or foot.

Ala (Lat. *ala*, a wing). Term applied to the lateral lobe of the nose, the expanded part of the external ear, and to certain processes of the sphenoid bone.

Alveoli (Lat. *alveus*, a cavity). The name given to the sockets of the teeth and the air-cells of the lung.

Amphiarthrosis (Gk. ἀμφί, about, and ἄρθρόν, a joint). An articulation by means of some intervening substance, as that between the bodies of the vertebræ.

Amygdalæ (Gk. ἀμυγδάλη, an almond). The tonsils are so called from their resemblance to almonds.

Anastomosis (Gk. ἀνα, by, and στομά, a mouth). The intercommunication of vessels.

Anatomy (Gk. ἀνα, through, and τέμνω, I cut). The Greek equivalent of "Dissection."

Anchylosis (Gk. ἀγκυλος, crooked). An unnatural union between bones.

Anconeus (Gk. ἄγκων, the elbow). A muscle situated near the elbow.

Annulus (Lat. *annulus*, a ring). A circle or ring.

ANTI—as in *anti-tragus*, *anti-helix*, &c. (Gk. ἀντί, against). Opposite, or opposed to.

ANTRUM (Lat. *antrum*, a cave). The cavity in the superior maxillary bone.

ANUS (Lat. *anus*, an opening). The termination of the rectum which serves as an outlet for the fæces.

AORTA (Gk. ἀορτήρ, a belt or strap to hang anything to). The main artery of the body is probably so called because it apparently suspends the heart.

APONEUROSIS (Gk. ἀπό, from, and νεῦρον, a nerve). A tendinous expansion, so called because the early anatomists did not distinguish between tendons and nerves.

APOPHYSIS (Gk. ἀπό, from, and φύω, I grow). A projection from the surface of a bone.

APPENDICES EPIPLOICÆ (Lat.). Small fringes of fat attached to the large intestine.

ARACHNOID (Gk. ἀράχνη, a spider's web, and εἶδος, like). The middle membrane of the brain.

ARCUATUM (Lat. *arcuatus*, bow-shaped). Name given, from their shape, to tendinous bands connecting the diaphragm with the last rib and first lumbar vertebra.

AREOLA (Lat. diminutive of *area*, a void space). Term applied to interspaces in fibrous tissue.

ARTERY (Gk. ἀήρ, air, and τηρέω, I keep). A vessel carrying blood from the heart. The ancients supposed the arteries contained air, and hence the name.

ARTHRODIA (Gk. ἄρθρόν, a joint). An articulation admitting of a gliding movement.

ARTHROLOGY (Gk. ἄρθρόν, a joint, and λόγος, a discourse). A treatise on joints.

ARTICULATION (Lat. *articulus*, a joint). The means by which the bones of the skeleton are connected.

ARYTENOID (Gk. ἀρύταινα, a pitcher, and εἶδος, like). The two pyramidal cartilages of the larynx, so called from the supposed resemblance of the two together to the mouth of a pitcher.

ASTRAGALUS (Gk. ἀστράγαλος, a die). One of the bones of the tarsus.

ATLAS (Gk. τλάω, I sustain). The vertebra which supports the head.

ATTOLLENS (Lat. *attollo*, I raise up). Raising. The attollens auriculam muscle raises the pinna.

ATTRAHENS (Lat. *ad*, to, and *traho*, I draw). Drawing towards. The anterior extrinsic muscle of the ear is so called because it draws the ear forwards.

AUDITORY (Lat. *audio*, I hear). Belonging to the ear.

AURICLE (Lat. *auricula*, diminutive of *auris*, a little ear). The two superior cavities of the heart are so called because of their appendices which look like ears.

AZYGOS (Gk. α, without, and ζυγός, a yoke). Without fellow. The term is applied to parts which are not in pairs.

BACILLARY (Gk. βακτηρία, a staff). The layer of rods and cones of the retina is sometimes called the bacillary layer.

BASILAR (Lat. *basis*, a base). Belonging to the base of the brain or skull.

BASILIC (Gk. βασιλικός, royal). A term generally of eminence, and hence applied to a large vein of the arm.
BICEPS (Lat. *bis*, twice, and *caput*, a head). Muscles having two heads receive this name.
BICIPITAL. Adjective from the preceding.
BICUSPID (Lat. *bis*, twice, and *cuspis*, a spear). Having two tubercles or points.
BIPENNIFORM (Lat. *bis*, twice, and *penna*, a feather). Applied to muscles having their fibres arranged on each side of a central tendon, like the barbs of a feather.
BRACHIA (Lat. *brachium*, an arm). Two arms of nerve matter in the interior of the brain.
BRACHIAL (Lat. *brachium*, an arm). Belonging to the arm.
BRONCHI (Gk. βρόγχος, the windpipe). The tubes which convey the air from the trachea to the lungs.
BRONCHOCELE (Gk. βρόγχος, the windpipe, and κήλη, a tumour). A permanent enlargement of the thyroid gland.
BUCCINATOR (Lat. *buccina*, a trumpet). A muscle of the cheek, so called from its use in blowing.
BULBUS (Lat. *bulbus*, an expanded underground stem). Applied to several rounded structures in the body, as the *bulbus olfactorius* and *bulbus vestibuli*.
BURSA (Lat. *bursa*, a sac). A closed sac containing fluid, and intended to modify pressure.

CÆCUM (Lat. *cæcus*, blind). Any *cul-de-sac* is called cæcum, but the term is especially applied to the expanded commencement of the large intestine.
CALAMUS SCRIPTORIUS (Lat. a writing pen). A groove upon the floor of the fourth ventricle.
CALCANEUM (Lat. *calx*, the heel). The heel bone.
CALX (Lat. *calx, calcis*, the heel). *Os calcis*, the bone of the heel.
CANALICULUS (Lat. diminutive of *canalis*, a canal). A small canal. The term is applied to the minute canals of bone, and to the passages which carry away the tears.
CANCELLI (Lat. *cancelli*, lattices). Term used to denote the spongy structure of bone.
CANINE (Lat. *canis*, a dog). The so-called canine teeth are largely developed in the dog.
CANTHI (Gk. κανθός, the angle of the eye). The angles formed by the junction of the eyelids.
CAPILLARIES (Lat. *capillus*, a hair). The minute vascular tubes in the tissues.
CAPITULUM (Lat. *capitulum*, a little head). Certain small rounded prominences receive this title, as the projection on the lower end of the humerus which articulates with the radius, and the lower extremity of the ulna (capitulum ulnæ).
CAPSULE (Lat. *capsula*, diminutive of *capsa*, a box). A bag enclosing any part or organ, as the capsule of the kidney.
CARDIAC (Gk. καρδία, the heart). Belonging to the heart.
CAROTID (Gk. καρόω, I induce sleep). The carotid arteries are so named because pressure on them is supposed to induce sleep.
CARPUS (Gk. καρπός, the wrist). The bones of the wrist.

CARUNCULA (Lat. diminutive of *caro*, flesh). A small flesh-like body.
CAUDA EQUINA (Lat. a horse's tail). The lower end of the spinal cord with the lumbar and sacral nerves.
CAVERNOUS (Lat. *cavus*, hollow). Hollow channels or cavities are called cavernous.
CEMENTUM (Lat. *cœmentum*, a rough stone). The substance which forms the exterior of the fang of a tooth.
CENTRUM (Lat. the centre). The body of a vertebra.
CEPHALIC (Gk. κεφαλή, the head). Belonging to the head.
CEREBELLUM (Lat. diminutive of *cerebrum*). The lesser brain.
CEREBRUM (Lat. the brain). The term applied to the greater brain or that part occupying the upper portion of the skull.
CERVIX (Lat. *cervix*, gen. *cervicis*, the neck).
CERUMINOUS (Lat. *cera*, wax). Glands secreting the ear wax.
CHIASMA (Gk. χιάζω, I mark with the letter X ; crossing or decussation). The commissure of the optic nerves.
CHOLEDOCHUS (Gk. χολή, bile, and δέχομαι, I receive). Conveying bile.
CHORION (Gk. χόριον, skin or leather). One of the membranes of the embryo.
CHOROID (Gk. χόριον, the chorion, and εἶδος, like). Term applied to the middle coat of the eye from its vascularity.
CHYLO-POIETIC (Gk. χυλός, juice, that is to say, chyle, and ποιέω, I make). Chyle-producing. Term applied to the viscera connected with the formation of chyle.
CILIA (Lat. *cilium*, an eyelash). The eyelashes.
CIRCUMDUCTION (Lat. *circum*, around, and *duco*, I lead). The slight degree of motion which takes place between the head of a bone and the socket, while the extremity of the limb is made to describe a large circle.
CIRCUMVALLATE (Lat. *circumvallatus*, trenched about).
CLAVICLE (Lat. *clavis*, a key). The collar bone.
CLEIDO-MASTOID (Gk. κλείς, a key, μαστός, a nipple, and εἶδος, like). Connected with the clavicle and mastoid process.
CLINOID (Gk, κλίνη, a bed, and εἶδος, like). The processes which border the sella turcica are so called because they bear some resemblance to the posts of a bedstead.
CLITORIS (Gk. κλειω, I shut up). The homologue in the female of the penis of the male.
COCCYX (Gk. κόκκυξ, a cuckoo). The last bone of the vertebral column in man. It is supposed to resemble a cuckoo's beak.
COCHLEA (Gk. κόχλος, a shell-fish). A spiral cavity in the internal ear.
CŒLIAC (Gk. κοίλια, the belly). Belonging to the belly.
COLON (Gk. κῶλον, the colon). The large intestine.
COMMISSURE (Lat. *committere*, to unite). A joining together.
COMPLEXUS (Lat. *complecti*, to comprise). A muscle at the back of the neck, so called because of the intricate mixture of its muscular and tendinous parts.
CONCHA (Gk. κόνχη, a shell). The central part of the external ear.
CONDYLE (Gk. κόνδυλος, a knuckle). Term applied to certain articular osseous processes.
CONJUNCTIVA (Lat. *con*, together, and *jungo*, I join). The mucous membrane of the front of the eye, which connects the lids with the eyeball.

Conoid (Gk. κῶνος, a cone, and εἶδος, like). A cone-shaped portion of the coraco-clavicular ligament is so called.
Constrictor (Lat. *constringere*, to bind tightly together). A muscle which constricts or closes any opening of the body.
Coracoid (Gk. κόραξ, a raven, and εἶδος, like). A process of the scapula supposed to resemble a raven's beak.
Corium (Gk. χόριον, leather). The deep layer of the skin.
Cornea (Lat. *corneus*, horny). The anterior transparent part of the eye.
Cornua (Lat. *cornu*, a horn). Processes which project like horns.
Corona (Lat. *corona*, a crown). Forming a circlet like a crown.
Corpus (Lat. *corpus*, a body, pl. *corpora*). A body. Hence we have the following :—

Corpora albicantia (Lat. *albico*, I become white). Two whitish masses of nerve substance at the base of the brain.
,, **Arantii.** Fibrous nodules in the semilunar valves of the heart, so named after the anatomist Arantius of Bologna.
,, **cavernosa** (Lat. *caverna*, a cavern). Two elongated bodies, formed of erectile tissue, and forming the chief bulk of the penis and clitoris.
,, **geniculata** (Lat. *geniculum*, a knot). Two small prominences of nerve matter situated at the back part of each thalamus opticus.
,, **quadrigemina** (Lat. *quadrigeminus*, four placed in two pairs). The masses of nerve matter with which the optic tracts are especially connected. They are also called *optic lobes*.
,, **striata** (Lat. *stria*, a streak). The great motor ganglia of the cerebrum ; their streaked appearance is due to the presence of alternate layers of grey and white matter.

Corpus callosum (Lat. *callus*, hard). The great transverse commissure of the brain.
,, **dentatum** (Lat. *dentatus*, toothed). A small mass of grey matter having an irregular outline, and situated in the centre of the cerebellum and in the olivary body.
,, **fimbriatum** (Lat. *fimbria*, a fringe). The fringed edge of the fornix as seen in the lateral ventricle.
,, **Highmorianum.** The central fibrous portion of the testicle, named after Highmore of Oxford.
,, **luteum** (Lat. *luteus*, pale yellow). The cicatrix left in the ovary from the bursting of a Graafian vesicle.
,, **spongiosum** (Lat. *spongia*, a sponge). The part of the penis which encloses the urethra.

Corpuscle (Lat. *corpusculum*, diminutive of *corpus*, a body). A small body.
Corrugator (Lat. *corrugare*, to wrinkle). A muscle which contracts the brow and produces wrinkles.
Costal (Lat. *costa*, a rib). Pertaining to the ribs.
Cotyloid (Gk. κοτύλη, a cup, and εἶδος, like). The cup-shaped cavity which receives the head of the femur.
Cranium (Gk. κρανίον, the skull). The skull.
Cremaster (Gk. κρεμάω, I suspend). The suspensory muscle of the testicle.
Cribriform (Lat. *cribrum*, a sieve, and *forma*, likeness). Sieve-like.

CRICOID (Gk. κρίκος, a ring, and εἶδος, like). One of the cartilages of the larynx.

CRISTA GALLI (Lat. a cock's comb). A comb-like process of the ethmoid bone.

CRUS (Lat. *crus*, a leg). A process or peduncle of the brain. *Crural—crureus.* Belonging to the leg.

CUBOID (Gk. κύβος, a cube, and εἶδος, like). A cube-shaped bone.

CUNEIFORM (Lat. *cuneus*, a wedge, and *forma*, likeness). Wedge-shaped.

CUNEUS (Lat. *cuneus*, a wedge). A wedge-shaped lobe of the brain.

CUTICLE (Lat. *cuticula*, diminutive of *cutis*, the skin). The superficial layer of the skin. Called also *epidermis*, and *scarf-skin.*

CYSTIC (Gk. κύστις, a bladder or bag). Belonging to the urinary or gall bladder.

DARTOS (Gk. δαρτός, flayed). The subcutaneous layer of the scrotum.

DEGLUTITION (Lat. *deglutire*, to swallow). The act of swallowing.

DELTOID (Gk. Δ, and εἶδος, like). The muscle and ligament thus named resemble in shape the Greek letter D.

DENTES SAPIENTIÆ (Lat. *dens*, a tooth, and *sapientia*, wisdom). Wisdom teeth.

DENTINE (Lat. *dens*, a tooth). The tissue forming the body of the tooth.

DERMA (Gk. δέρμα, the skin). The deeper layer of the skin; called also *true skin.*

DESCENDENS NONI (Lat. *descendens*, descending, and *noni*, of the ninth). The descending branch of the ninth cranial nerve.

DIAPHRAGM (Gk. διάφραγμα, a partition wall). The muscle which separates the cavity of the abdomen from that of the thorax.

DIAPHYSIS (Gk. δία, through, and φύω, I grow). A term applied to the shaft of a long bone.

DIARTHROSIS (Gk. δία, through, and ἄρθρόν, a joint). A joint with a moderate degree of motion.

DICHOTOMOUSLY (Gk. δίχα, double, and τέμνω, I cut). Dividing into pairs.

DIGASTRIC (Gk. δίς, twice, and γαστήρ, a belly). Two-bellied.

DIGITAL FOSSA (Lat. *digitus*, a finger, and *fossa*, a ditch). A depression such as might be produced by the tip of the finger.

DIPLOË (Gk. διπλοῦς, double). The osseous tissue between the two tables of the skull.

DISC (Lat. *discus*, a flat plate).

DISSECT (Lat. *disseco*, I cut to pieces).

DUODENUM (Lat. *duodeni*, twelve). The first portion of the small bowel was thus named by Herophilus, because it is twelve fingers' breadth in length.

DURA MATER (Lat. *dura*, hard, and *mater*, mother). The outer membrane of the brain.

EMBRYO (Gk. ἐν, in, and βρύω, to bud forth). The fœtus in utero.

EMULGENT (Lat. *emulgeo*, I milk or drain out). Term applied to the renal arteries.

ENAMEL (Gk. ἐν, in, and Fr. *émail*). The hard substance covering the crown of a tooth.

ENARTHROSIS (Gk. ἐν, in, and ἄρθρόν, a joint). A ball-and-socket joint, in which the rounded head of one bone is received into the cup-shaped socket of another.

ENCEPHALON (Gk. ἐν, in, and κεφαλή, the head). The brain.
ENDOCARDIUM (Gk. ἐνδον, within, and καρδία, the heart). The membrane lining the cavities of the heart.
ENDOSTEUM (Gk. ἐνδον, within, and ὀστεον, a bone). The membrane which lines the interior of long bones.
ENSIFORM (Lat. *ensis*, a sword, and *forma*, shape). The terminal piece of the sternum.
ENTROPIUM (Gk. ἐν, in, and τρόπω, I turn). Inversion of the margin of the eyelid.
EPHIPPIUM (Gk. ἐφίππιον, a saddle). The ridge forming the back of the sella turcica is called *dorsum ephippii.*
EPICRANIUM (Gk. ἐπί, upon, and κρανίον, the skull). The periosteum of the skull.
EPIDERMIS (Gk. ἐπί, upon, and δέρμα, skin). The superficial layer of the skin.
EPIDIDYMIS (Gk. ἐπί, upon, and δίδυμος, the testicle). A small lobule connected with the testicle.
EPIGASTRIUM (Gk. ἐπί, upon, and γαστήρ, stomach). The region of the abdomen in which part of the stomach lies.
EPIGLOTTIS (Gk. ἐπί, upon, and γλῶττις, the glottis). The cartilage which covers the opening of the glottis in deglutition.
EPIPHYSIS (Gk. ἐπί, upon, and φυω, I grow). The portions of long bones which grow by centres distinct from that of the shaft.
EPIPLOIC (Gk. ἐπί, upon, and πλέω, I sail). Belonging to the omentum, this being called *epiploon.*
EPITHELIUM (Gk. ἐπί, upon, and θαλλω, I grow). So called because it generally forms the superficial layers of tissues.
ERECTOR (Lat. *erigere*, to raise).
ERYTHROID (Gk. ερυθρος, red, and εἶδος, like). Reddish. A term applied to the cremaster muscle where it covers the spermatic cord.
ETHMOID (Gk. ἠθμός, a sieve, and εἶδος, like). A bone so called from the perforations in its horizontal plate.
EXTENSOR (Lat. *extendere*, to stretch out). A muscle which extends a part.

FACET (Fr. *facette*, a little face). A small plane surface.
FALCIFORM (Lat. *falx*, a scythe, and *forma*, like). Scythe-like.
FALLOPIAN TUBES. The ducts for the passage of the ovum from the ovary to the uterus; so called after Gabriel Fallopius, the anatomist who first described them.
FALX CEREBRI (Lat. *falx*, a scythe, and *cerebrum*, the brain). A scythe-like process of the dura mater separating the two hemispheres of the brain.
FASCIA (Lat. *fascia*, a bundle). A sheet composed of bundles of fibrous tissue.
FASCICULUS (Lat. diminutive of *fascia*, a bundle). A small bundle of muscular or nerve fibres.
FAUCES (Lat. plural of *faux*, the throat). The opening between the mouth and pharynx.
FEMUR (Lat. *femur*, the thigh). The thigh bone.
FENESTRA (Lat. *fenestra*, a window). Term applied to the openings between the middle and internal ear.
FIBRIL (Lat. *fibril*, a fibre). A small filament or fibre.

FIBRILLÆ (Lat. diminutive of *fibril*).
FIBULA (Lat. *fibula*, a clasp). The lesser bone of the leg.
FILIFORM (Lat. *filum*, a thread, and *forma*, like). Thread-like.
FILUM TERMINALE. The thread by which the spinal cord is fixed at its lower extremity.
FIMBRIÆ (Lat. *fimbriæ*, fringes). The fringes of the Fallopian tube.
FLEXOR (Lat. *flectere*, to bend). A muscle which bends the limb.
FLOCCULUS (Lat. diminutive of *floccus*, a lock of wool). The part of the cerebellum on which the pneumogastric nerve lies.
FŒTUS (Lat. *fœtus*, the young of any creature). The child in utero after the fourth month.
FOLLICLE (Lat. diminutive of *follis*, a bag). A small cavity with open mouth.
FONTANELLES (Lat. diminutive of *fons*, a fountain). The spaces between the cranial bones in the fœtus.
FORAMEN (Lat. *foramen*, a hole).
FORNIX (Lat. *fornix*, an arch or vault). An arched commissure of the brain.
FOURCHETTE (Fr. *fourchette*, a fork). The thin fold which connects the labia majora posteriorly.
FOVEA (Lat. *fovea*, a pit). A shallow depression.
FRÆNUM (Lat. *frænum*, a curb or bridle). Any part which performs the office of a check or curb; more especially applied to a band of mucous membrane.
FUNDUS (Lat.). The bottom.
FUNGIFORM (Lat. *fungus*, and *forma*, shape). Shaped like a mushroom.

GALACTOPHORUS (Gk. γάλα, milk, and φέρω, I carry). Term applied to the ducts of the mammary glands.
GANGLION (Gk. γάγγλιον, a tumour or enlargement). A nerve centre.
GASTRIC (Gk. γαστήρ, the belly). Pertaining to the stomach.
GASTROCNEMIUS (Gk. γαστήρ, the belly, and κνήμη, the leg). The muscle which forms the bulk of the bellied part of the leg.
GEMELLUS (Lat. dim. of *geminus*, double). Twin muscles.
GENIAL (Gk. γένειον, the chin). Belonging to the chin.
GENICULATE (Lat. *geniculum*, a little knee). A ganglionic swelling on a bend of the facial nerve is called *geniculate*.
GENIO-HYO-GLOSSUS (Gk. γένειον, the chin, and γλῶσσα, the tongue). A muscle attached to the chin, hyoid bone, and tongue.
GENIO-HYOID. A muscle attached to the chin and hyoid bone.
GINGLYMUS (Gk. γιγγλυμός, a hinge). A hinge-joint.
GLANS (Lat. *glans*, an acorn). The extremity of the penis or clitoris.
GLENOID (Gk. γλήνή, a socket, and εἶδος, likeness). The name of a part having a shallow cavity, as the shoulder-joint, and a fossa in the temporal bone.
GLOBUS (Lat. *globus*, a ball). Term applied to part of the epididymis.
GLOMERULUS (Lat. dim. of *glomus*, a ball of thread). The vascular tufts of the kidneys.
GLOSSO—(Gk. γλῶσσα, the tongue). Terms compounded of this word belong to nerves or muscles connected with the tongue.
GLOTTIS (Gk. γλῶττις). The mouth of the wind-pipe.
GLUTEUS (Gk. γλουτός, the buttock). The name given to the chief muscles of the buttock.

GOMPHOSIS (Gk. γόμφος, a nail). A nail-like articulation, as that of the teeth with the jaws.
GRACILIS (Lat. *gracilis*, slender). A long, thin muscle of the thigh.
GUBERNACULUM (Lat. *guberno*, I steer or guide). The cord which guides the testicle in its descent.
GUSTATORY (Lat. *gusto*, I taste). Connected with taste.
GYRUS (Gk. γύρος, a ring). A convolution.

HÆMAL (Gk. αἷμα, blood). Containing the blood-vessels.
HÆMAPOPHYSIS (Gk. αἷμα, blood, and ἀπόφυσις, a process of bone). The name given to the processes of bone forming the sides of the hæmal arch in the typical vertebra.
HÆMORRHOIDAL (Gk. αἷμα, blood, and ῥέω, I flow). A term applied to those vessels which bleed in piles.
HAMULAR (Lat. *hamus*, a hook). Hook-shaped.
HARMONIA (Gk. ἁρμοζω, I fit together). An articulation in which the bones are joined together without serration of the edges, or the intervention of cartilage.
HAVERSIAN. A term given from the name of their discoverer, Havers, to a very complicated system of minute canals found in the substance of bone.
HELICO-TREMA (Gk. ἕλιξ, a spiral, and τρῆμα, a hole). The hole between the two scalæ of the cochlea.
HELIX (Gk. ἕλιξ, a spiral). Having a spiral form. *Helicine.*
HEPATIC (Gk. ἡπατικός, of the liver). Relating to the liver.
HIATUS (Lat. *hio*, I open). An irregular opening.
HIPPOCAMPUS (Gk. ἱπποκάμπος, a sea-horse). Convolutions of the brain supposed to resemble a sea-horse.
HYALINE (Gk. ὕαλος, glass). Transparent and apparently structureless.
HYOID (Gk. υ, the letter upsilon, and εἶδος, likeness). The hyoid bone, so named from its shape.
HYDROCEPHALIC (Gk. ὕδωρ, water, and κεφαλή, the head). Relating to water in the head.
HYO-EPIGLOTTIC. Connecting the hyoid bone and epiglottis.
HYPOCHONDRIUM (Gk. ὑπό, under, χόνδρος, cartilage). The upper lateral region of the abdomen, situated under the cartilages of the false ribs.
HYPOGASTRIC (Gk. ὑπό, under, and γαστήρ, the stomach). Beneath the stomach.
HYPOGLOSSAL (Gk. ὑπό, under, and γλῶσσα, the tongue). Beneath the tongue.
HYPOPHYSIS (Gk. ὑπό, under, and φύσις, from φύω, I grow). The pituitary gland is called *hypophysis cerebri*, because it is connected with the under surface of the anterior part of the brain.
HYPOTHENAR (Gk. ὑπό, under, and θέναρ, the palm of the hand).

ILEUM (Gk. εἰλέω, I roll up). The lower three-fifths of the small intestine; so called from its convolution.
ILIAC (Lat. *ilia*, the flanks). Belonging to the ilia or flanks.
INFRAORBITAL (Lat. *infra*, beneath, and *orbs*, a circle). Beneath the circle of the eye.
INFUNDIBULUM (Lat. *infundibulum*, a funnel or tunnel). A funnel-shaped opening or canal.
INGUINAL (Lat. *inguin*, the groin). Belonging to the groin.

Inosculation (Lat. *in*, in, and *osculum*, a little mouth). The union of vessels, or anastomosis.
Integument (Lat. *in*, in, and *tego*, to cover). The skin.
Internodia (Lat. *internodium*, the space between two knots). The interspaces between the joints of the fingers.
Interosseous (Lat. *inter*, between, and *os*, a bone). Between the bones.
Iris (Gk. *ἶρις*, the rainbow). The iris is so called from its bright colours.
Ischium (Gk. *ἰσχίον*, the hip). The hip bone.

Jejunum (Lat. *jejunus*, empty). The upper two-fifths of the small intestine, so named from this portion being generally found empty after death.

Labia (Lat. pl. of *labium*, a lip). The lips. *Labia majora*, the two large folds forming the external orifice of the pudendum, and the *labia minora*, the two smaller folds situated within them.
Labyrinth (Gk. *λαβύρινθος*, a maze). The internal ear.
Lacerum (Lat. *lacerum*, a torn opening). A term applied to irregular openings seen in the base of the skull.
Lachrymal (Lat. *lachryma*, a tear). Pertaining to the tears.
Lacunæ (Lat. *lacus*, a lake). Small cavities.
Lambdoidal (Gk. letter Λ, lambda, and *εἶδος*, likeness). Formed like the Greek letter Λ.
Larynx (Gk. *λάρυγξ*, the larynx). The upper part of the windpipe.
Latissimus dorsi (Lat. *latissimus*, broadest, and *dorsum*, the back). The broadest muscle of the back.
Laxator (Lat. *laxare*, to loosen). A muscle of the tympanum attached to the handle of the malleus.
Lenticular (Lat. *lens*, *lentis*, a lentil). Lens-shaped.
Levator (Lat. *levare*, to lift up). A muscle which raises any part.
Ligament (Lat. *ligare*, to bind). A membrane which connects the articular surface of bones and cartilages, and sometimes protects the joint by a capsular envelope.
Linea aspera (Lat. *linea*, a line, and *asper*, rough.)
Lingual (Lat. *lingua*, a tongue). Relating to the tongue.
Locus perforatus (Lat. *locus*, a place, and *perforatus*, bored). A perforated space.
Lumbricales (Lat. *lumbricus*, an earth-worm). The name of certain muscles of the hand and foot, so called from their resemblance to the earth-worm.
Lunula (Lat. *lunula*, dim. of *luna*, the moon). The small white portions at the root of the nail.
Lymph (Lat. *lympha*, water). A colourless liquid of an alkaline character which fills the lymphatic vessels.
Lymphatics (from preceding). The term applied to vessels containing lymph.
Lyra (Lat. *lyra*, a lyre). The name given to that part of the fornix which presents the appearance of some white lines somewhat resembling the strings of a lyre.

Maceration (Lat. *macerare*, to make soft by steeping). The steeping of a body for some time in water, spirit, ether, wine, or vinegar, for purposes of softening.

MALAR (Lat. *mala*, the cheek). Belonging to the cheek.
MALLEOLAR (Lat. *malleolus*, dim. of *malleus*, a hammer). A term applied to two projections of bone which overhang the ankle-joint.
MALLEUS (Lat. *malleus*, a hammer). The hammer bone, one of the small bones of the ear.
MASSETER (Gk. μασσάομαι, I chew). One of the chief muscles of mastication.
MASTOID (Gk. μαστός, a breast, and εἶδος, likeness). A prominence which resembles the nipple of the breast.
MAXILLARY (Lat. *maxilla*, the cheek bone). Belonging to the jaws.
MEATUS (Lat. *meatus*, a passage). A passage.
MEDIASTINUM (Lat. *medius*, middle, and *sto*, I stand. The space left between the two pleural sacs in the cavity of the thorax.
MEDULLA (Lat. *medius*, middle). Marrow, situated in the middle of the bones.
MEMBRANE (Lat. *membrana*, the skin of an animal). A thin substance lining a cavity.
MENINGES (Gk. μῆνιγξ, a membrane). The membranes of the brain.
MENSTRUATION (Lat. *menstrua*, pl. of *menstruus*, a monthly allowance). The periodical discharge from the female generative organs of a bloody fluid poured out by the inner surface of the uterus.
MENTAL (Lat. *mentum*, the chin). Belonging to the chin.
MESENTERY (Gk. μέσος, middle, and ἔντερον, an intestine). The membrane which suspends the small intestines from the posterior wall of the abdomen ; a reflection of the peritoneum.
MESIAL (Gk. μέσος, middle). In the middle line.
MESO- (Gk. μέσος, middle). A term compounded with other words to attach the meaning of middle to these words.
META- (Gk. μετά, beyond). A Greek preposition prefixed to anatomical terms to convey the idea of further distance, as in metacarpus, beyond the carpus.
MODIOLUS (Lat. *modiolus*, the nave of a wheel). The central osseous column of the cochlea.
MOLAR (Lat. *mola*, a millstone). Grinding teeth.
MONS PUBIS (Lat. *mons*, a mountain, and *pubes*, one of the bones of the pelvis). The elevation of the pubes.
MONTICULUS CEREBELLI (Lat. *monticulus*, little mountain, and *cerebellum*, the lesser brain). A small projection on the cerebellum.
MUCIPAROUS (Gk. μυξα, the mucus of the nostrils, and *parire*, to produce). Producing mucus.
MUCUS (Gk. μυξα, the mucus of the nostrils). The liquid secreted by the mucous surfaces of the body.
MULTICUSPIDATI (Lat. *multus*, many, *cuspis*, a spear). The name of the last three molars.
MYLO-HYOID (Gk. μύλη, a millstone). Attached to the lower jaw (part of the mill), and the hyoid bone.
MYOLEMMA (Gk. μῦς, a muscle, λεμμα, a membrane). A delicate sheath investing the ultimate fibril of muscular tissue.
MYOLINE (Gk. μῦς, a muscle). A transparent substance combined in the cells which constitute the ultimate fibril of muscular tissue.
MYOIDES (Gk. μῦς, a muscle, and εἶδος, likeness). Platysma myoides.
MYRTIFORM (Gk. μύρτος, a myrtle berry, and Lat. *forma*, likeness). A fossa on the superior maxillary bone is so called on account of its shape.

NARES (Lat. *nares*, the nostrils). The cavities of the nose.
NASAL (Lat. *nasus*, the nose). Belonging to the nose.
NAVEL (Sax. *nafela*, from *nafa*, nave). The vernacular name for the depression in the middle of the abdomen, being the scar left by the detachment of the umbilical cord after parturition.
NAVICULAR (Lat. *navicula*, a small ship). Term applied to the boat-like or scaphoid bone of the wrist.
NECROSIS (Gk. *νεκροω*, I mortify). Term used to denote death of the bone.
NERVES (Lat. *nervus*, a string or cord). White cords arising from the brain, or the spinal marrow, and distributed over every part of the system.
NUCLEUS (Lat. *nucleus*, a kernel). A body usually found in the centre of a cell.
NYMPHÆ (Gk. Νυμφαι, Nymphs). Two folds of mucous membrane situated within the labia majora of the pudendum, so called because they direct the course of the urine.

OBTURATOR (Lat. *obturo*, I stop up). An aperture in the innominate bone which in the recent state is nearly closed by a membrane.
OCCIPITAL (Lat. *occiput*, the back of the head). Belonging to the back of the head.
OCCIPUT (Lat. *ob*, *caput*, against the head). The back part of the head; the part opposite to the front or *sinciput*.
ODONTOID (Gk. *ὀδοὺς*, a tooth, and *εἶδος*, likeness). Resembling a tooth.
ŒDEMA (Gk. *οἴδημα*, from *οἰδεω*, to swell). An infiltration of the subcutaneous areolar tissue.
ŒSOPHAGUS (Gk. *οἰω*, *οισω*, I carry, and *φάγειν*, to eat). The gullet.
OLECRANON (Gk. *ὠλένη*, the elbow, and *κρᾶνον*, the head). The tip of the elbow.
OLFACTORY (Lat. *olfacere*, to smell). Belonging to the sense of smelling; the name of the first pair of cerebral nerves.
OLIVARY (Lat. *oliva*, an olive). The olivary bodies are two olive-shaped eminences of the *medulla oblongata*.
OMENTUM (Lat. *omentum*, the caul wherein the bowels are wrapped—Ainsworth).
OMO-HYOID (Gk. *ὦμος*, the shoulder). Attached to the shoulder and the hyoid bone.
OPHTHALMIC (Gk. *ὀφθαλμός*, the eye). Belonging to the eye.
OPPONENS (Lat. *opponens*, opposing). A term applied to a muscle which brings the thumb inwards, so as to oppose the fingers.
OPTIC (Gk. *ὀπτομαι*, to see). Belonging to the sight.
ORBICULAR (Lat. *orbiculus*, a little orb). Having a spherical or circular form; a name given to several muscles.
OS (ORIS) (Lat. *os*, *oris*, the mouth). A mouth; a passage or entrance into any place.
OS (OSSIS) (Lat. *os*, *ossis*, a bone). A bone.
OS CALCIS (Lat. *os*, a bone, and *calx*, the heel). The bone of the heel.
OSSA TRIQUETRA (Lat. *os*, a bone, and *triquetrus*, having three corners). Small triangular bones sometimes found in the lambdoidal suture.
OSSEOUS (Lat. *os*, a bone). Bony, formed of bone.
OSSICULA (Lat. *ossiculum*, a little bone). Little bones.
OSTEODENTINE (Lat. *os*, a bone, and *dens*, a tooth). A peculiar form of dentine, approaching closely to bone in its structure.

OSTEOGENESIS (Gk. ὀστέον, a bone, and γένεσις, formation). The development of bone.
OSTEOLOGY (Gk. ὀστέον, a bone, and λόγος, a discourse). A description of bones.
OSSIFICATION (Lat. *os*, a bone). The act of the formation of bone.
OTIC GANGLION (Gk. οὖς, an ear, and γάγγλιον, a tumour). A small ganglion near the ear.
OTOCONIA (Gk. οὖς, the ear, κόνις, dust). Minute particles of calcareous sand found in the membranous labyrinth of the ear.
OTOLITHS (Gk. οὐς, the ear, and λίθος, a stone). Synonymous with otoconia.
OVARIAN (Lat. *ovum*, an egg). Pertaining to the ovary.
OVUM (Lat. *ovum*, an egg).

PACCHIONIAN GLANDS. Small round whitish granulations found in connection with the membranes of the brain and called after Pacchioni.
PACINIAN. Pacinian corpuscles are found on the peripheral extremities of the nerve fibres, chiefly in the palm of the hand and the sole of the foot, and are named after Pacini, an Italian anatomist.
PALPEBRÆ (Lat. *palpebrare*, to wink). The eyelids.
PAMPINIFORM (Lat. *pampinus*, a tendril, and *forma*, likeness). Plexus of veins of the testicle.
PANCREAS (Gk. πᾶν, all, and κρέας, flesh). A conglomerate gland situated transversely across the posterior wall of the abdomen. It is also called sweet-bread.
PAPILLÆ (Lat. *papillæ*, teats). The small conical eminences situated on the tongue and the deep layer of the skin.
PAR VAGUM (Lat. *par*, a pair, and *vagus*, wandering). The eighth pair of nerves.
PARIETAL (Lat. *paries*, the wall of a house). The term applied to two of the bones of the cranium.
PAROTID (Gk. παρά, near, and οὖς, the ear). The salivary gland situated just in front of the ear.
PATELLA (Lat. *patella*, a small pan). The knee-pan, or cap of the knee.
PECTINEAL (Lat. *pecten*, the pubic bone). The term applied to prominences of the pubic bone.
PECTORALIS (Lat. *pectus*, the breast). The term applied to two muscles of the breast.
PELVIS (Lat. *pelvis*, a basin). The osseous girdle which contains the internal organs of generation.
PENIS (Lat. *penis*, a tail). The male organ of generation.
PENNIFORM (Lat. *penna*, a feather, and *forma*, likeness). Feather-shaped; a term applied to those muscles that have their fibres arranged on one side of a long tendon.
PEPTIC (Lat. *pepticus*, digestive).
PERFORANS (Lat. *perforare*, to pierce through). A designation of the *flexor profundus digitorum* from its perforating the tendon of the flexor sublimis.
PERICARDIUM (Gk. περί, around, and καρδία, the heart). The membrane which surrounds the heart.
PERICHONDRIUM (Gk. περί, around, χόνδρος, cartilage). The membrane that covers the free surface of cartilage.

PERICRANIUM (Gk. *περί*, around, and *κρᾶνιον*, the cranium). The periosteum of the cranium.

PERINEUM (Gk. *περί*, around, and *ναίω*, I am situated). The space between the anus and the scrotum, or anus and vagina.

PERIOSTEUM (Gk. *περί*, around, and *όστεον*, a bone). The membrane which covers the outside of a bone.

PERITONEUM (Gk. *περί*, about, and *τείνω*, I stretch). The serous membrane which lines the abdominal and pelvic cavities.

PERONEAL (Gk. *περόνη*, the pin of a buckle). Belonging to the fibula.

PES (Lat. *pes*, the foot). A term applied to parts resembling a foot.

PES ANSERINUS (Lat. *pes*, a foot, and *anserinus*, belonging to a goose). The goose's foot. The name of a plexus of nerves formed by the facial, or portio dura of the seventh pair, on the side of the face.

PES ACCESSORIUS (Lat. *pes*, a foot, and *accessio*, an addition). A swelling at the junction of the posterior and middle horns of the lateral ventricles.

PES HIPPOCAMPI (Lat. *pes*, a foot, and *hippocampus*). The termination or foot of the hippocampus major.

PETROUS (Gk. *πέτρα*, a rock). The term applied to the hardest portion of the temporal bone. *Petrosal.*

PEYER'S PATCHES. The groups of lymphoid nodules in the small intestine.

PHALANX (Gk. *φάλαγξ*, a rank of soldiers). A term applied to the bones of the fingers, and toes from their regularity.

PHARYNX (Gk. *φάρυγξ*, the throat). The upper part of the food passage.

PHRENIC (Gk. *φρήν*, the mind). Belonging to the diaphragm. The ancients supposed the diaphragm to be the seat of the mind, and hence they called it *phrenes*.

PIA MATER (Lat. *pia*, tender, and *mater*, mother). The innermost membrane of the brain.

PINEAL (Lat. *pineus*, a pine). A small body, situated in the interior of the brain, is called the *pineal gland.*

PINNA (Lat. *pinna*, a feather). The expanded part of the external ear.

PISIFORM (Lat. *pisum*, a pea). A bone of the wrist shaped like a pea.

PITUITORY (Lat. *pituita*, the secretion of the nostrils). The gland thus named was so called because it was erroneously supposed to be the source of the nasal mucus.

PLACENTA (Lat. *placenta*, a cake). The after-birth.

PLANTARIS (Lat. *planta*, the sole of the foot). A muscle which in the plantigrade animals makes tense the fascia of the sole of the foot.

PLATYSMA (Gk. *πλάτυσμα*, a plate). *See* MYOIDES.

PLEURA (Gk. *πλευρά*, side). A membrane which covers the inside of the ribs, and the outside of the lungs.

PNEUMOGASTRIC (Gk. *πνεύμων*, the lung, and *γαστήρ*, the stomach). The great nerve distributed to the larynx, lungs, heart, and stomach.

POMUM ADAMI (Lat. *pomum*, an apple). Adam's apple. The anterior prominence of the thyroid cartilage.

POPLITEAL (Lat. *poples*, the ham). The space behind the knee is so called, and certain nerves and vessels in it receive the same name.

PORTAL (Lat. *porta*, a gate). The great vein which enters the liver through the transverse fissure ("gate of the liver") is so named.

PORTIO DURA (Lat. *portio*, a part, and *dura*, hard). The firmest of the two portions forming the seventh pair of nerves.

POUPART'S LIGAMENT. The lower border of the aponeurosis of the external

oblique muscle of the abdomen, attached to the anterior superior spine of the ilium and spine of the pubes.

PROFUNDUS (Lat. *profundus*, deep).

PRONATOR (Lat. *pronus*, face downwards). Muscles bringing the hand to the *prone* position are thus named.

PROSTATE (Gk. *πρό*, before, and *ἵστημι*, I stand). A glandular body which stands in front of the bladder.

PSOAS (Gk. *ψόα*, the loin). A muscle of the loin.

PTERYGOID (Gk. *πτέρυξ*, a wing, and *εἶδος*, like). Wing-like processes.

PUBES (Lat. *pubescens*, covered with hair).

PUDIC (Lat. *pudeo*, I am ashamed). The arteries and nerves going to the perineum and external organs of generation are thus named.

PULMONARY (Lat. *pulmo*, the lung). Belonging to the lungs.

PUNCTUM (Lat. *punctum*, a point).

PYLORUS (Gk. *πυλωρὸς*, a gate-keeper). The lower opening of the stomach.

PYRIFORMIS (Lat. *pyrus*, a pear). A pear-shaped muscle.

QUADRATUS (Lat. *quadratus*, square). The name of several muscles having a square form.

QUADRICEPS (Lat.) Having four heads.

QUADRIGEMINA (Lat. *quadrigeminus*, four arranged in two pairs). Name given to the optic lobes of the brain, from their division into four.

RACEMOSE (Lat. *racemus*, a cluster of grapes). Clustered.

RACHIDIAN (Gk. *ῥάχις*, the spine). Belonging to the spinal column.

RADIUS (Lat. *radius*, a ray or spoke of a wheel). One of the bones of the forearm.

RAMUS (Lat. *ramus*, a branch).

RANINE (Lat. *rana*, a frog). This word seems to be derived from *ranula*, an affection which is supposed to resemble a frog.

RAPHÉ (Gk. *ῥαφή*, a seam). The line of junction of two lateral parts.

RECTUS, RECTUM (Lat. *rectus*, straight). A straight muscle or tube.

RENAL (Lat. *ren*, the kidney). Belonging to the kidney.

RESTIFORM (Lat. *restis*, a cord). A cord-like band.

RETINA (Lat. *rete*, a net). The nervous network of the eye. From the same root we have *rete* mucosum, *rete* testis, and others.

RISORIUS (Lat. *rideo*, I laugh). The *risorius Santorini* is the muscle which produces the sardonic smile.

ROTULA (Lat. dim. of *rota*, a wheel). The patella.

RUGÆ (Lat. *ruga*, a wrinkle). Term applied to certain folds of mucous membrane.

SACCULUS (Lat. dim. of *saccus*, a bag). A membranous bag in the internal ear.

SACRUM (Lat. *sacrus*, sacred). The sacrum was offered as a sacrifice by the ancients.

SAGITTAL (Lat. *sagitta*, an arrow). Term applied to the straight suture between the parietal bones.

SALPINGO-PHARYNGEUS (Gk. *σάλπιγξ*, a trumpet). Name given to a muscle which passes from the Eustachian tube to the pharynx.

SAPHENOUS (Gk. *σαφηνής*, manifest). Name given to the superficial veins of the leg, because they are usually prominent.

SARCOLEMMA (Gk. σάρξ, flesh, and λέμμα, a covering). The covering of the muscular fibres.
SARTORIUS (Lat. *sartor*, a tailor). The muscle thus named is used in crossing the legs.
SCALA (Lat. *scala*, a stair). Three spiral passages in the cochlea are so called.
SCALENUS (Gk. σκαλήνος, a geometrical figure having three unequal sides). The name of several muscles of the neck which are triangular in shape.
SCAPHOID (Gk. σκαφή, a boat, and εἶδος, like). Anything having a boat-shape.
SCAPULA (probably from Gk. σκαπάνη, a spade). The shoulder-blade.
SCHINDYLESIS (Gk. σχινδύλεω, I cleave). An articulation in which the prominent spine of one bone is placed between two laminæ of the other, like a wedge into the wood it splits. The best example of this is the articulation of the rostrum of the sphenoid with the vomer.
SCIATIC. *See* ISCHIATIC.
SCLEROTIC (Gk. σκλερός, hard). The dense outer tunic of the eye.
SCROTUM (Lat. *scrotum*, a leather bag). The pouch which contains the testicles.
SEBACEOUS (Lat. *sebum*, suet). The glands which lubricate the hairs are thus named.
SELLA TURCICA (Turkish saddle). The hollow on the upper surface of the sphenoid is so called from its supposed resemblance to a Turkish saddle.
SEPTUM (Lat. *sepio*, I hedge in). A partition.
SERRATUS (Lat. *serra*, a saw). The muscles which bear this name are so called from the resemblance of their costal attachments to the teeth of a saw.
SESAMOID (Gk. σησάμον, sesame, and εἶδος, like). Bones contained in tendons of muscles.
SIGMOID (Gk. ς, old form of sigma, and εἶδος, like). Cavities which resemble in shape the old Greek letter *sigma*.
SINUS (Lat. *sinus*, a hollow). A cavity or cell : also a venous channel, as those in the dura mater and heart.
SKELETON (Gk. σκέλλω, I dry). The dry bones of any animal.
SOLEUS (Lat. *solea*. a sandal ; also a sole fish). A muscle which bears some resemblance to a sole fish.
SPERMATOZOA (Gk. σπέρμα, seed, and ζῶον, an animal). The generative cells of the male. *Spermatic.*
SPHENOID (Gk. σφήν, a wedge, and εἶδος, like). The bone so named wedges in the other bones of the base of the skull.
SPHINCTER (Gk, σφιγγω, I contract). A term applied to those muscles which close an aperture.
SPLANCHNIC (Gk. σπλάγχνον, a viscus or intestine). Nerves which go chiefly to the intestines.
SPLEEN (Gk. σπλήν, the spleen). The spleen.
SPLENIUS (Lat. *splenium*, a pad). A muscle of the neck.
SQUAMOUS (Lat. *squama*, a scale). A scale-like piece of bone.
STAPEDIUS (Lat. *stapes*, a stirrup). The muscle of the stirrup bone of the ear.
STERNUM (Gk. στέρνον, the breast or chest). The breast bone.
STOMATA (Gk. στόμα, the mouth). Small openings between the epithelial cells of serous membranes.

STYLOID (Gk. στῦλος, a style or pen, and εἶδος, like). An osseous process which resembles an ancient *stylus.*

SUBLIMIS (Lat. *sublimis*, high). Superficial.

SUDORIFEROUS (Lat. *sudor*, sweat, and *fero*, I bear). Term applied to the sweat glands and their ducts.

SULCUS (Lat. *sulcus*, a hollow). A hollow between convolutions of the brain.

SUPINATOR (Lat. *supinus*, lying face upwards). Muscles which bring the arm to such a position that the palm of hand looks upwards are called supinators.

SURAL (Lat. *sura*, the calf of the leg). Belonging to the calf.

SUTURE (Lat. *sutura*, a seam). The union of two bones by rough edges.

SYMPHYSIS (Gk. σύν, together, and φύω, I grow). "An articulation in which there is no manifest motion" (Hoblyn).

SYNARTHROSIS (Gk. σύν, together, and αρθρόν, a joint). An articulation in which there is complete fixture.

SYNCHONDROSIS (Gk. σύν, together, and χόνδρος, cartilage). An articulation partly cartilaginous and partly fibrous.

TÆNIA (Gk. ταινία, a band). The term is applied to certain bands of nerve matter in the brain.

TARSUS (Gk. ταρσός, the upper surface of the foot). The bones of the posterior part of the foot.

TEGMENTUM (Lat. *tegere*, to cover). Term applied to the upper strand of the crus cerebri, and to the roof of the tympanic cavity.

TELA (Lat. *tela*, a web). A term applied to web-like tissues.

TEMPORAL (Lat. *tempora*, the temples, from *tempus*, time). Belonging to the temples.

TENDON (Gk. τείνω, I stretch). The fibrous extremity of a muscle, by which it is attached to bone.

TENSOR (Lat. *tendere*, to stretch). A term conventionally applied to a muscle which stretches any part.

TENTORIUM (Lat. *tentorium*, a tent). A process of the dura mater.

TERES (Lat. *teres*, round).

THALAMUS (Gk. θάλαμος, a bed). The part of the brain against which the optic nerves rest at their commencement is called *thalamus opticus.*

THECA (Gk. θήκη, a case). The sheaths of the tendons of the fingers are called *thecæ.*

THENAR (Gk. θέναρ, the palm of the hand). The mass of muscles forming the ball of the thumb is called the *thenar prominence.*

THORAX (Gk. θώραξ, a breastplate). The chest.

THYMUS (Lat. *thymus*, thyme). A gland found in the upper part of the chest of young animals.

THYROID (Gk. θυρεός, a shield, and εἶδος, like). Shield-shaped.

TIBIA (Lat. *tibia*, a pipe or flute). The large bone of the leg.

TORCULAR HEROPHILI (Lat. *torcular*, a wine-press). The meeting of the sinuses of the brain on the occipital bone. Literally it means the "wine-press of Herophilus."

TRABECULÆ (Lat. dim. of *trabs*, a beam). Fibrous bands in the interior of such organs as the spleen, lymphatic glands, and penis.

TRACHEA (Gk. τράχυς, rough). The wind-pipe. It was formerly called *arteria trachea*, the "rough air-passage;" rough from its cartilages.

TRACHELO—(Gk. τράχηλος, the neck). Connected with the neck.
TRAGUS (Gk. τράγος, a goat). A process of the external ear.
TRAPEZIUM, TRAPEZIUS (Gr. τραπεζα, a table). Having a tabular form.
TRICEPS (Lat. *tres*, three, and *caput*, a head). Having three heads.
TRICUSPID (Lat. *tres*, three, and *cuspis*, a point). Name given to the right auriculo-ventricular valve from its being composed of three flaps.
TRIGONE (Gk. τρεῖς, three, and γωνία, an angle). A triangle at the base of the bladder.
TRIQUETRA. *See* OSSA TRIQUETRA.
TROCHANTER (Gk. τροχάω, I roll or turn). Two prominences of the femur are so named.
TROCHLEA (Gk. τροχός, a wheel). A kind of pulley.
TURBINATED (Lat. *turbo*, a whirl). The term is applied to certain coiled bones in the nasal cavities.
TYMPANIC (Lat. *tympanum*, the drum of the ear). Belonging to the cavity of the middle ear, or to the drum.
TYSON'S GLANDS. Sebaceous glands situated around the *corona* of the penis, and named after Tyson, who first described them.

ULNA (Gk. ὠλένη, the elbow). One of the bones of the forearm.
UMBILICUS (Lat. *umbilicus*). The navel.
UNCINATE (Lat. *uncus*, a hook). Hooked.
UNGUAL (Lat. *unguis*, a nail). Belonging to the nail.
URACHUS (Gk. οὖρον, urine, and ἔχω, I hold). A cord which forms one of the ligaments of the bladder. It is the remains of the umbilical vesicle of the embryo.
URETER (Gk. οὐρέω, I pass water). The tube which conveys the urine from the kidney to the bladder.
URETHRA (Gk. οὖρον, urine). The tube which conveys the urine from the bladder.
UTERUS (Lat. *uterus*. the womb).
UVEA (Lat. *uveá*, grape). The posterior layer of the iris, named from its resemblance in colour to a grape.
UVULA (Lat. dim. of *uva*, a grape). The small tongue which depends from the centre of the soft palate.

VAGINA (Lat. *vagina*, a sheath). The term is generally restricted to the vulvo-uterine canal.
VELUM (Lat. *velum*, a veil). A thin membranous layer which covers any part.
VENTER (Lat. *venter*, the belly).
VERTEBRÆ (Lat. *vertere*, to turn). The segments of the spinal column. So called because they turn on each other.
VILLI (Lat. *villus*, shaggy hair). Small processes on the mucous membrane of the small intestine.
VINCULA (Lat. *vincula*, a small chain). Accessory bands found in the sheaths of the tendons of the fingers.
VISCERA (Lat. *viscus*, pl. *viscera*, one of the internal organs of the body). The internal organs.
VITREOUS (Lat. *vitrum*, glass). The transparent mass which occupies the posterior part of the globe of the eye.
VOLAR (Lat. *vola*, the palm of the hand). Belonging to the palm.

VOMER (Lat. *vomer*, a ploughshare). The central bone of the nose.
VULVA (Lat. *volvere*, to roll). The genital opening of the female, enclosed by the labia majora.

WORMIAN. The ossa triquetra are sometimes called Wormian bones from Olaus Wormius, who first described them.

XIPHOID (Gk. *ξίφος*, a sword, and *εἶδος*, like). The lower piece of the sternum.

ZYGOMA (Gk. *ζυγός*, a yoke). Joining together the bones of the side of the head and face.

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